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Comparing the Predictive Capabilities of Level Three EVM Cost Data with Level Five EVM Cost Data

Joshua D. Johnson

COMPARING THE PREDICTIVE CAPABILITIES OF LEVEL THREE EVM COST DATA WITH LEVEL FIVE EVM COST DATA

THESIS

Joshua D Johnson, Captain, USA

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Joshua D Johnson, BS

Captain, USA

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Joshua D Johnson, BS

Captain, USA

Approved:

__________//signed//__________________	_28 February 2014_
Edward D. White, PhD (Chairman)	Date
__________//signed//__________________	_28 February 2014_
Lt Col Jonathan D. Ritschel (Member)	Date
__________//signed//__________________	_28 February 2014
William Stockman, PhD (Member)	Date

AFIT-ENC-14-M-04

Abstract

Contract cost growth has been a concern for the Department of Defense (DoD) for decades. Earned value management is a tool used by the DoD to assist in identifying cost overruns before they occur. Current DoD regulations require contracts to report their earned value management (EVM) data down to level three of the work breakdown structure (WBS). Previous research has shown level three EVM data can predict contract cost growth earlier than using level one EVM data. This research examines if level five EVM data would better predict cost growth than level three. The results indicate that level five is not a better predictor of cost growth then level three. Thus, the results do not support the DoD requiring contractors to provide level five EVM data.

Acknowledgments

I thank my family for their continuous support throughout this thesis process as well as in all phases of my life. I also express my sincere appreciation to my faculty advisors, Dr. Edward White and Lt Col Dan Ritschel, for their guidance throughout the course of this thesis effort. I certainly appreciated their insight and experience.

Joshua D Johnson

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COMPARING THE PREDICTIVE CAPABILITIES OF LEVEL THREE EVM COST DATA WITH LEVEL FIVE EVM COST DATA

Chapter 1 – Introduction

Background

The Department of Defense (DoD) outsources most major acquisitions projects to different private companies; so it is imperative for the DoD to have effective oversight of these projects. Earned value is the method the DoD has decided to use in order to achieve this oversight. In 1967, the DoD created the Cost/Schedule Control Systems Criteria (C/SCSC). The C/SCSC used thirty-five different formulas to assist program managers and commanders in determining if a project was on budget and on schedule. The Earned Value Management System (EVMS) replaced C/CCSC in 1997.

Earned value management has been successful in assisting program managers and commanders with oversight of programs for over fifteen years. As in any profession, the evaluation and rewards of contracts depend upon the contractor's performance. However, there are some concerns with EVMS as well. Some contractors learn how to beat, or at least go around, the system. Some project managers learn how to manipulate their earned value numbers in order to have their programs appear on time and budget, when in reality, the program manager is aware the program is not (CIO Insight, 2005). For example, if a project manager says a task is 80% complete, EVMS might allege the project is on time and on budget. However, what proof is there that the task is 80% complete, not just 40% complete? Slight changes in the completion percentage can make

a large impact on the actual status of a project (CIO Insight, 2005). This issue of intentional misrepresentation will always be a concern for the DoD.

Another concern for the DoD with EVMS, not involving intentional misrepresentation, is what level to report cost data using EVMS formulas. There are currently three techniques to evaluate cost data: a top level showing the total project cost, a bottom level breaking the cost down to the lowest level (control account), or the third option of somewhere in between. Each of these three techniques has positive and negative aspects, respectively.

Using top-level cost data (Work Breakdown Structure (WBS) level 1), the project manager is able to obtain a quick picture of the overall status of a project. The negative aspects of this approach are that the overall project might currently be on budget and schedule, even if there is a lower level element that is falling behind schedule or over budget. This could cause the entire project to fall behind or go over budget. Because the purpose of EVMS is to predict future problems, top level cost data would show only the current state of the project with limited predicative capabilities.

Using bottom level cost data (control accounts) is a practice widely used by companies in the private sector who use EVMS (DAU Website, 2013). Using this level of cost data allows the project manager to see exactly what area(s) have the greatest risk of going over budget or falling behind schedule. The disadvantages of using these cost data is that the project manager now has to track many different data points, and it drives up the management cost due to the extra accounting work and man-hours to prepare the data.

Currently, the DoD uses the third method. The current requirements are for contractors to report cost down to work breakdown structure level three. However, there are some exceptions to this rule. High-risk or high-cost elements in a project require a lower collection of cost data. The reason for requiring this level is that the government "does not want to constrain the contractor's ability to define or manage the program and resources" (MIL-STD-881C, 2011).

Purpose of Research

The purpose of this research is to determine the predictive nature of EVM when the government has visibility of cost data down to level five of the WBS. Currently, the government requires its contractors to provide cost data only at level three of the WBS. Knowing there are additional costs associated with obtaining additional information from the contractor, is it beneficial for the government to pay the additional cost?

The cost of any DoD contract can be broken down into two main areas, the Total Allocated Budget (TAB) and profits and fees. The TAB is the sum of all budgeted costs for a contract. The dollar value of the TAB can fluctuate throughout the contract life and on contracts. The Budget at Complete (BAC) and the TAB can be interchangeable on contracts (DAU Gold Card, 2013). Figure 1 displays the relationship between the contract price and its components. Found in Appendix A, are a complete list of EVM acronyms.

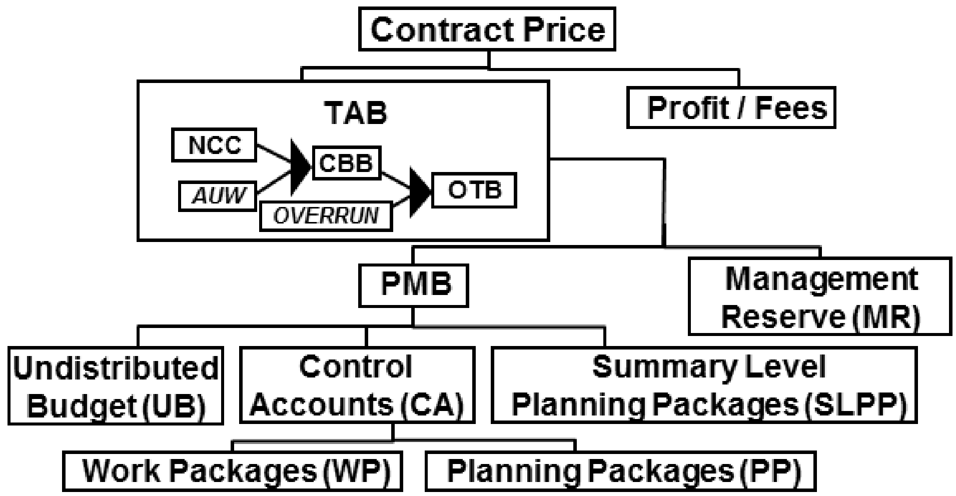


Figure 1- Contract Price Diagram

The work breakdown structure (WBS) divides all government projects (MIL-STD-881C, 2011). The WBS divides the overall project into multiple layers of smaller sub components, which allows the government to monitor and track what tasks, or parts, are required to complete the project. However, contractors also use an organizational breakdown structure (OBS). The OBS, like the WBS, divides the different parts of a project, but instead of breaking the different parts down by product, the OBS breaks the parts down by which department of the organization will actually work on the part. The control account is where the WBS and OBS meet. Figure 2 illustrates a generic relationship between the WBS and the OBS. However, the figure gives the impression that the control account is located at level five of the WBS, which might not be true. Every program will have different levels in its WBS. The DoD has attempted to standardize only the first three levels of the program WBS.

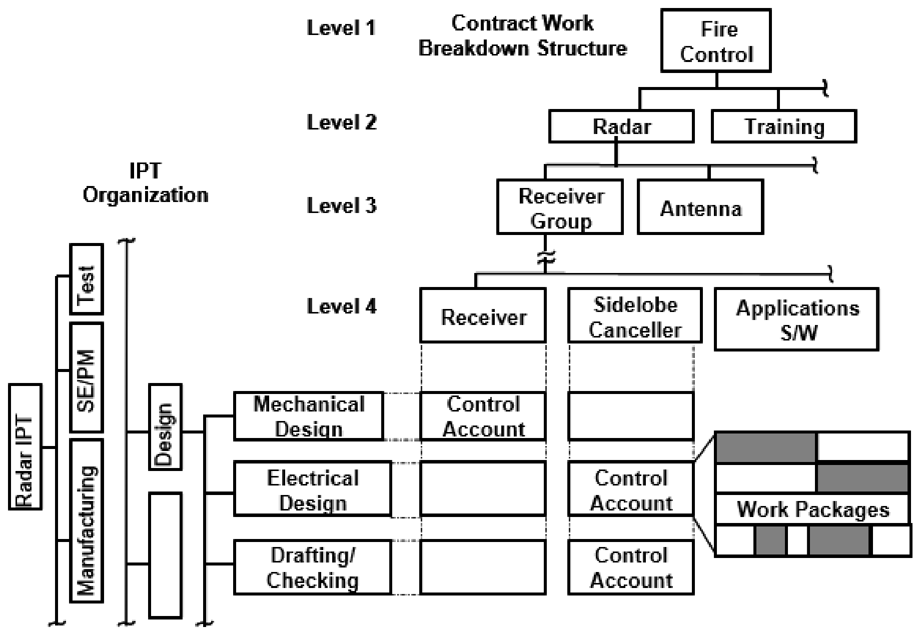


Figure 2 - CWBS and OBS Intersection

This research looks into the comparison of earned value management at level five compared to the current reporting standard of level three of the WBS. Currently, when a contractor reports the status of a project to the government, the contractor is required to show the project's cost information down to the third level of the contract WBS. Program managers and analysts use cost information to predict if the project is on schedule and budget in various EVM formulas. This research investigates if it would be more beneficial for the government if the contractors would provide cost information down to level five.

<u>Research Objective</u>

The main objective of this research is to determine if level five EVM data will predict overall cost growth earlier and more accurately than level three EVM data. Then if level five is more predictive, how much extra would it cost the DoD to obtain this data

and is the extra cost worth any additional value level five data has? Previous research has proven the benefits of using level three EVM data compared to level one EVM data (Rosado, 2011). However, due to inconsistencies in the data available, Rosado was unable to research below level three.

Research Questions #1

The primary question is if level five EVM data is more predictive than level three EVM data at predicting overall contract cost growth. If level five data is not more predictive, the government should not invest additional money into the contract. To answer this research question we evaluated the following three investigation questions:

Investigation Question #1.1

Which EVM metric should we use to predict cost growth? Rosado used the EAC provided by the contractor to compare cost growth while Keaton also included the cost performance index (CPI) and schedule performance index (SPI).

Investigation Question #1.2

Our last investigating question for research question #1 is can we build a statistical model using levels three and five EVM data to predict overall contract performance?

Research Questions #2

The next research question is what is the additional cost associated with requiring contractors to provide level five EVM data? In addition, should we have the contractor include all level five elements or just a certain percentage based on the size of each level five element compared to the overall size of the contract?

Methodology

We plan to use a regression-based approach to determine the relationship between our level three and five EVM data and the overall contract cost growth. Regression-based models have been widely used in previous research to predict cost growth (Rosado, 2011; Trahan, 2009; Thickstun, 2010). However, Trahan and Thickstun both looked at top-level EVM data while Rosado examined level three EVM data. We believe we will be able to look down to level five due to an improvement in EVM reporting.

The Office of Performance Assessments and Root Cause Analyses (PARCA) is the organization that oversees earned value management within the Department of Defense (DoD) (PARCA Website). PARCA is continually attempting to improve the implementation of EVM data.

> PARCA's goal is to increase earned value's constructive attributes for the DoD firms managing acquisition programs by reducing the economic burden of inefficient implementation of EVM. PARCA is dedicated to the concept that EVM is a management tool, not merely a contractually required report (PARCA Website)

Using the Earned Value Management – Central Repository (EVM-CR), we have access to approximately "30,000 Contractor Cost Data Reports (CCDR), Software Resources Data Reports (SRDR) and associated documents (DCARC Website, 2013)." In addition, from talking with an analyst at PARCA, he estimated there are approximately 177 contracts within the EVM-CR that contain level five EVM data (Pflieger, 2013).

After we run our regression models, we need to clarify we are not attempting to show causality between overall contract growth and our independent variables. We are attempting to show that the relationship between our independent variables and EAC

growth act as predictors. Our goal is to create a regression model that will provide an early warning to project managers and analysts of possible cost growth within a contract. We ultimately want to identify if level five EVM data can predict that growth earlier and more accurately than level three data.

Assumptions

For our research, we made two key assumptions about the EVM data available. The first assumption we have to make is the contracts with level five EVM data are not biased. As we stated earlier in this chapter, contractors are required to report below level three for contracts that are considered high risk or high cost. The risk we are assuming is that not all of the available contracts with level five EVM data are just either high risk or high cost. Another assumption we made was that the WBS data available was contract WBS not program WBS. What this means to our research is that we will not attempt to prove a program's overall cost growth. Instead, we will be looking at individual contract's cost growth.

Overview of Thesis Chapters

In the following chapter, we will fully explain the origins of earned value and discuss previous research completed on relevant topics. In Chapter Three, we will explain how we obtained our data and how we selected the data points we will use in our model. Then, we will continue to explain our methodology on how we will analyze and evaluate our data. In Chapter Four, we will show the results of our statistical model. During the final chapter, we will give a conclusion and some possible follow-on research problems.

Chapter 2 - Literature Review

Purpose

The purpose of this chapter is to review relevant literature dealing with earned value management system (EVMS). In this chapter, we will define the major parts as well as look at the history of earned value and why it is important. We will then discuss research dealing with problems of the effectiveness of the DoD's earned value system operations. In addition, we will provide some information on completed relevant research.

Define Work Breakdown Structure

Understanding the parts of a problem is the best way to understanding the problem. The first area we are going to explain is a work breakdown structure and its intended uses. Segmentation occurs with the WBS into two types of WBSs. The first type is a Program Work Breakdown Structure (PWBS). The other type of WBS is the Contract Work Breakdown structure (CWBS). Both types of WBS break down the elements of a project into logical levels (MIL–STD 881, 2011).

The Program WBS shows the entire program at a summary level. The program WBS will consist of at least three levels (Albert, 2008). The DoD standardizes these three levels. Contractors use PWBSs to report the status of their projects to the DoD. Only the top three levels of the WBS are required because requiring additional lower levels could affect a contractor's methods and cause delays in processes due to the additional reporting requirements (Albert, 2008). Level one of the WBS ascertains the entire item usually identified as a major program or a project within an aggregated

program. Levels two and three recognize the elements of the parent level broken down to their next logical steps. Figure 3, from MIL STD 881C, displays a simple relationship between the first five levels of the WBS (MIL STD 881C, 2011).

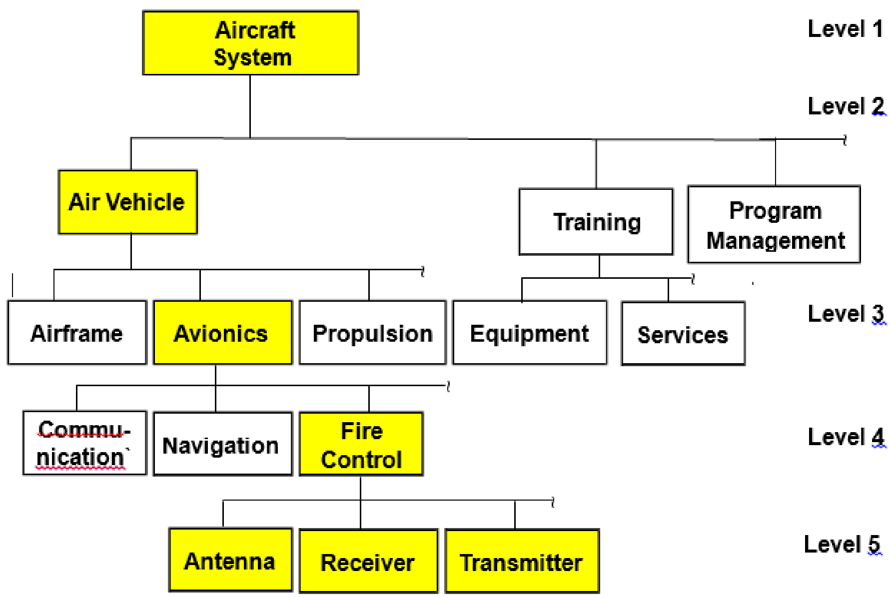


Figure 3 - Simple PWBS

The contractor uses the other type of WBS, the CWBS. The CWBS will normally start where the PWBS stops and continues down to at least one level below the negotiated DoD reporting level. In most cases, the contractors will have their CWBS going all the way down to the control account level. The benefits of the CWBS for the contractor are that the CWBS allows the contractor to break the work down into manageable size elements. By breaking the work down to a manageable level, the contactor can track the individual people working on a project and determine exact cost and schedule data for each element. The lowest level of the WBS is the control account. The control account is where the WBS intercepts the organizational breakdown structure (OBS).

The main difference between the PWBS and the CWBS is standardization. The DoD has developed twelve different standardized PWBS. MIL-STD 88c contains a breakdown of each WBS structure. The reason for twelve different WBS is the differences between types of project. These standardizations assist the DoD when evaluating similar projects, indicating one will have the ability to find the same elements in levels one through three for a C-130 or an F-35. In contrast, in a contract WBS, the elements can vary by how the contractor decides to break down each element. The standardization reason for the PWBS, while the CWBS is not, is because the DoD is responsible for developing and maintaining the PWBS, while the individual contractor is responsible for the CWBS (Albert, 2008).

Earned Value

In this section, we will explain what earned value is and explain some earned value terms and definitions. We will also go into the need for earned value and its purpose within the DoD.

Terms and Definitions

Analysts often uses the following terms interchangeably; earned value analysis, earned value management, and earned value management system. However, there is a distinctive difference between each of these terms (Lukas, 2008). The following definitions are from Lukas's article "Earned Value Analysis-Why it Doesn't Work":

• Earned Value Analysis (EVA) - a quantitative project management technique for evaluating project performance and predicting final project results, based on

comparing the progress and budget of work packages to planned work and actual costs.

• Earned Value Management (EVM) – a project management methodology for controlling a project, which relies on measuring the performance of work using a Work Breakdown Structure (WBS) and includes an integrated schedule and budget based on the project WBS.

• Earned Value Management System (EVMS) – the process, procedures, tools and templates used by an organization to do earned value management.

As one can see from these definitions, each of these terms is different. However, each is dependent on the other.

For earned value to work properly within any organization there must be five basic data elements. They are as follows; Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV), Budgeted Cost of Work Performed (BCWP) or Earned Value (EV), Actual Cost of Work Performed (ACWP) or Actual Cost (AC), Budget at Complete (BAC) or Planned Cost, and Estimate at Complete (EAC) or Forecasted Cost. Table 1 displays the five core elements used with earned value in the DoD (Air Force Cost Analysis Handbook, 2007).

Table 1 - Five Basic Elements for Earned Value

Element	Title	Common Terminology
BCWS	Budgeted Cost of Work Scheduled	Planned Value (PV), Performance Measurement Baseline (PMB), plan, baseline
BCWP	Budgeted Cost of Work Performed	Earned Value (EV)
ACWP	Actual Cost of Work Performed	Actual Cost (AC), actuals
BAC	Budget at Complete	Planned Cost
EAC / LRE	Estimate at Complete / Latest Revised Estimate	Forecasted Cost

Figure 4 illustrates the basic relationship between the cumulative values of the five basic elements of EVM (DAU Gold Card, 2013).

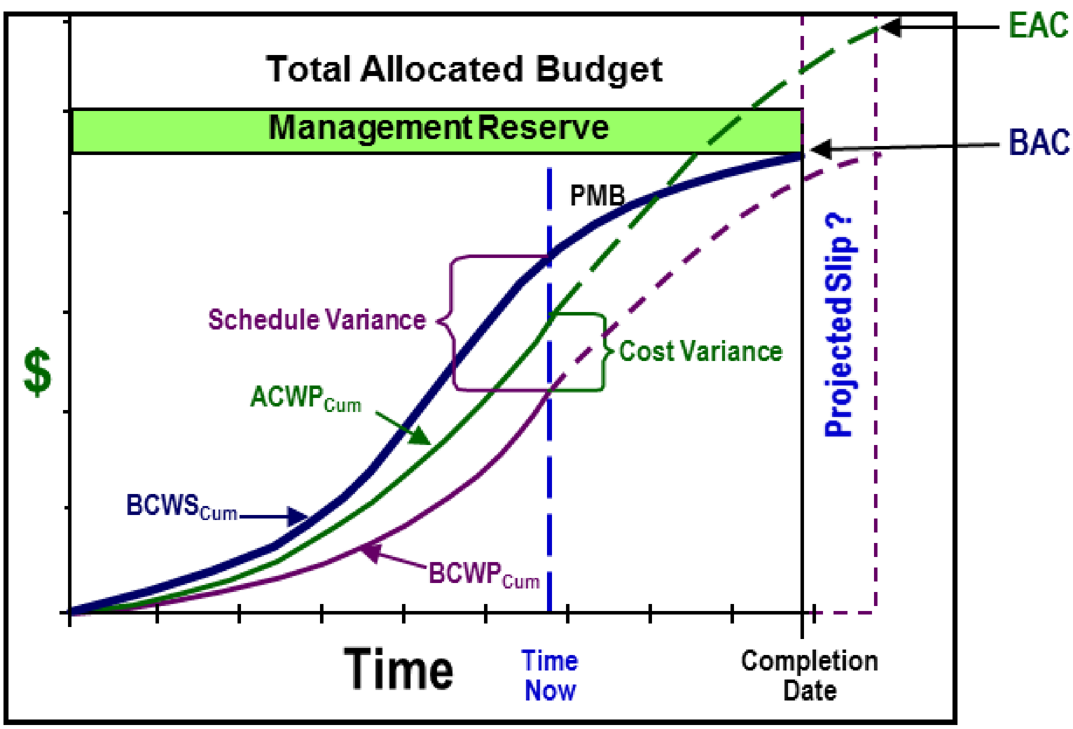


Figure 4 - Relationship between EVM elements

As Figure 4 indicates, the ACWP will equal the EAC at the end of the contract and the BCWS and BCWP should both equal the BAC at the end.

Figure 5 displays the relationship between PV, AC and EV (Lukas, 2008):

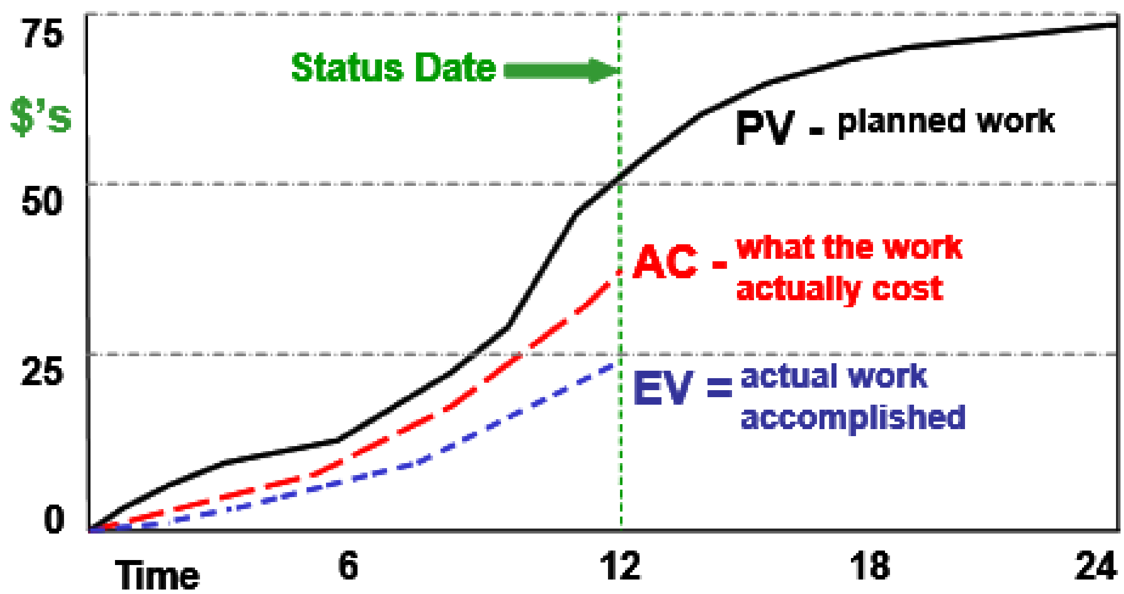


Figure 5 - Relationship between EVM elements

Figure 5 illustrates the status at the time the project was budgeted to have spent $50 but actually spent only about $35. At first glance, this looks positive until earned value is also considered. At the time of the status date, the project actually earned only $25 worth of value. With these three data points, a project manager can immediately calculate the cost variance (CV), schedule variance (SV), cost performance index (CPI), and schedule performance variance (SPI).

The cost variance indicates the difference between the earned value and the actual cost. If the CV is less than zero, it means costs are higher than the value earned to date.

If the CV is greater than zero, it demonstrates costs are lower than the value earned to date (Lukas, 2008).

$$CV = EV - AC$$

The schedule variance shows the difference between the earned value and the planned or budgeted value. If the SV is less than zero, it demonstrates less work accomplished than one planned to date. If the SV is greater than zero, it demonstrates more work accomplished that one planned to date (Lukas, 2008).

$$SV = EV - PV$$

The cost performance index shows a ratio comparing the earned value with the actual value. The CPI determines the value of every dollar spent on a project. The CPI shows the percentage of value gained for every dollar invested. The CPI demonstrates less money earned on the project than invested if it is less than one (not getting a full dollar's worth of work). The CPI demonstrates more money earned on the project than invested if it is more than one (Air Force Cost Analysis Handbook, 2007).

$$CPI = EV / AC$$

The schedule performance index shows a ratio comparing the earned value with the planned value. The SPI shows the efficiency of the work accomplishments. If the SPI is less than one, it show less work has been done than planned, while if it is greater than one it shows more work has been done than planned (Air Force Cost Analysis Handbook, 2007).

$$SPI = EV / PV$$

Figure 6 displays how the CV, SV, CPI, and SPI relate with the PV, AC, and EV.

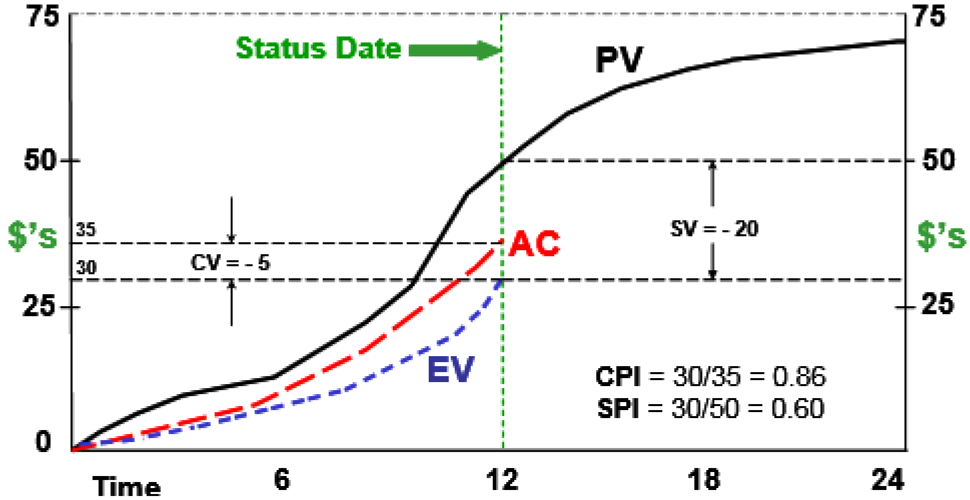


Figure 6 - Earned Value Analysis

The earned value calculations in Figure 6 convey to us the current state of the project. While this information is important, one of the main purposes of EVMS is to predict the estimate at complete (EAC) or final cost of a project from the information we have now. According to Joseph Lukas, there are three different ways for calculating the EAC.

EAC_1 assumes the CPI will remain 1.0 for the rest of the project. This method assumes that even if the project has been running behind schedule it will automatically correct itself for the remainder of the contract. This formula produces the most optimistic outcome for a project.

$$EAC_1 = AC + (BAC - EV)$$

EAC_2 is entitled the CPI forecast. This formula assumes past cost performance is the only indicator for future performance. It assumes the CPI will remain constant during the rest of the project.

$$EAC_2 = BAC/CPI$$

EAC_3 is entitled the CPI * SPI Forecast. Considered the most pessimistic or worst case, this formula assumes past cost and schedule performance are indicators for future performance (Lukas, 2008).

$$EAC_3 = BAC/(CPI \times SPI)$$

The Defense Acquisitions University Earned Value Management Gold Card gives two different ways to calculate the EAC, the EAC_{CPI} and the $EAC_{Composite}$. The formula below, demonstrates how the EAC_{CPI} is calculated (DAU Gold Card, 2013):

$$EAC_{CPI} = ACWP + [BAC – BCWP]/ CPI$$

or

$$EAC_{CPI} = AC + [BAC – EV] / CPI \text{ shows}$$

The $EAC_{Composite}$ is similar to Lukas's EAC_3. The below formula demonstrates how the $EAC_{Composite}$ is calculated.

$$EAC_{Composite} = ACWP + [BAC – BCWP]/ [CPI * SPI]$$

or

$$EAC_{Composite} = AC + [BAC – EV] / [CPI * SPI]$$

Figure 7 displays how the EAC is calculated.

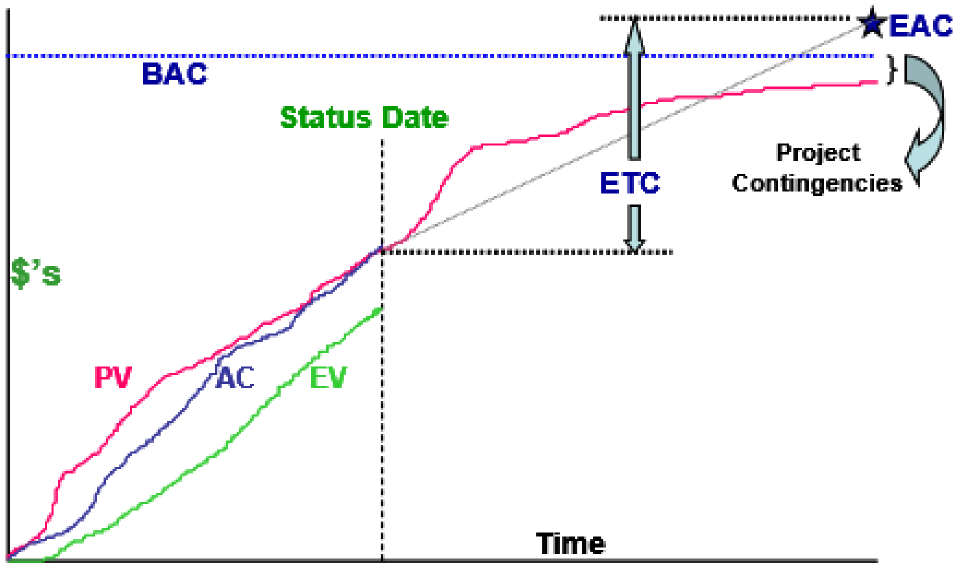


Figure 7 - Estimate at Complete

The EAC at complete is the summation of the ACWP, or AC, and the Estimate to complete (ETC).

Another formula that is widely used, when analyzing EVM data, is percent complete. The final budgeted amount compared to where the project is demonstrates the percent complete. However, the literature shows percent complete calculated two different ways. The most commonly used formula is by dividing the BCWP by the BAC (Thickstun, 2010; DAU, 2013; Christensen and Templin, 2002). The other method we have seen percent complete calculated is by dividing ACWP by the BAC (Trahan, 2009). Table 2 illustrates the two different formulas and the definition for each acronym.

Table 2 - Percent Complete Formulas

% Complete = $\frac{BCWP}{BAC}$	ACWP:	Actual Cost of Worked Performed
	BCWP:	Budgeted Cost of Worked Performed
% Complete = $\frac{ACWP}{BAC}$	BAC:	Budget at Completion

<u>History of Earned Value in the DoD</u>

Earned value has four major evolutions within the DoD over the past six decades. The DoD first started to use a form of earned value back in 1957 with the Navy's Polaris missile project, entitled program evaluation and review technique (PERT). The original purpose of PERT was to help management create a network model showing the logical steps to complete a project while focusing on time and the probability of success of the project. In less than five years, this method needed replacing (Fleming and Koppelman, 1998).

In 1962, the U.S. Air Force expanded on the original PERT by adding resources to the network model, entitling the new technique PERT/Cost. The evaluation of changes in a project was the most important achievement of PERT/Cost. Until this time, the evaluation process was comparing cost plans with the actual cost for each project. With PERT/Cost, project managers compared the value of the work to the actual cost. Today, we look at this as a simple idea, but in the 1960s, this changed the process of project evaluations. Similar to PERT, PERT/Cost lasted only three years (Fleming and Koppelman, 1998).

Even though the DoD decided to stop using PERT/Cost, it still believed earned value concept had merit and decided to retain earned value as a tool to evaluate a project.

In 1967, the DoD formally implemented earned value with Cost/Schedule Control System Criteria (C/SCSC). Based on the best practices from private industry since the early 1900s, C/SCSC required defense contractors to provide a minimum standard for reporting program performance, as well as requiring contractors to integrate their cost, schedule and effort into a single master plan. C/SCSC was a major improvement with earned value. Managers finally had the resources to predict the final total cost and project length more accurately (GAO-09-3SP, 2009).

Cost/Schedule control system criteria were DoD's first major use of earned value to evaluate projects. However, there were many problems with the system. One of the biggest problems was the rigid requirements. This issue caused some contractors to maintain two sets of data for a project. One set would be the company's working data used to manage the project. To meet the DoD's requirements, contractors maintained a second set of data (GAO, 2009). Another issue contractors had with C/SCSC was the contractor thought that C/SCSC did not add value to their projects by requiring them to complete all the requirements for the DoD (Fleming and Koppelman, 1998).

At the end of 1996, the DoD decided to discontinue C/SCSC due to the problems C/SCSC was causing with the contractors. To create an improved earned value system, the DoD, along with private industry, created the Earned Value Management System (EVMS). When the DoD implemented EVMS, in 1997, the DoD stated, "they brought EVM back to its intended purpose of integrating cost, schedule, and technical effort for managers and providing reliable data to decision makers" (GAO-09-3SP, 2009).

Problems with Earned Value Management System in the DoD

Even with the evolution of earned value over the past six decades, the lingering question of the best way to evaluate data still exists. Solomon has written multiple times about his concern on the proper way companies report their EVM data. He states that in the current DoD system, a contractor could report 100% complete for EVM; however, the project fails to meet the technical requirements (Solomon, 2006; Solomon, 2013).

Lukas also expresses concerns with how earned value is calculated. He suggests there needs to be a quantitative method to assess the project, not a qualitative approach. Stating a qualitative approach could lead to team biases (Lukas, 2008).

Etxegoien expresses concerns about risk in incorporated EVM values. Stating that risk, which is initially added to the contract, is "locked in time with the EVMS baseline while the actual risk is measured and track separately (Etxegoien, 2002)."

Bushey and Etxegoien both also state that the current EVMS is too restrictive for program managers. In both of their researches, they mention program managers need for more freedom to choose what level to report elements. They also mention the current negative connotation of rebase lining hinders program managers from admitting a program might be going over budget. They mention this fear could lead program managers to misrepresent the actual status of a program (Bushey, 2007; Extxegoien, 2002).

Relevant Research Completed

Quantitative research about cost growth into lower level EVM data is very limited. Most research using EVM data looks only at level one. We are attempting to

determine the most beneficial level for the DoD to calculate its EVM data. We have found only one study that used quantitative data to evaluate lower level EVM data. The limited amount of research in this area is because there is not a lot of EVM data that goes down that low. However, we did find multiple qualitative studies supporting lower level EVM data is more predictive and should be used (DAU Website, 2013). However, for the DoD, we require that the contractor only report EVM data at level three of the WBS (MIL-STD-881C, 2011).

Rosado (2011) conducted the only quantitative study on lower level EVM data found in our literature review. Rosado had two main goals for his research. The usage as an early warning for cost growth within a contract was the first intention in the creation of a regression model using lower level WBS EVM data. His second intent was to determine which specific program element contributed the most to overall cost growth.

Rosado, however, used only level three WBS elements in his models. The reason he did not go deeper down the WBS tree was due to lack of commonality of program elements. He wanted to be able to compare like elements in the different programs to see how they predict the overall cost growth. Since there is no standardization below level three, Rosado was unable to use lower level elements. He concluded his research by finding a strong relationship between level three DT&E elements and the overall program EAC growth (Rosado, 2011).

While Rosado conducted the only quantitative research, Bushey (2007) and Etxegoien (2002) both conducted qualitative research on the subject. Etxegoien looked at how program managers can better use EVM data. The current standardized requirements constrain the program manager’s ability to track and forecast cost growth. At whatever

level is necessary to give clarity to the program manager, he recommends collecting EVM data. He also recommends collecting EVM data to the lowest level possible on elements that fall within the critical path of the program. Etxegoien does not use any quantitative models to support his argument. His logical argument gave a large basis for his recommendations (Etxegoien, 2002).

Bushey, like Etxegoien, looks at how program managers can best use EVM data. In his research, he says the best way to detect a problem early is to have visibility of the EV data at the smallest level. He states that by drilling down to the lower levels, a program manager can easier identify root causes for cost growth or schedule slippage. He also states that the ability to view the lower level (control account) EVM data allows the program manager to be able to talk directly with the control account manager (CAM). By speaking directly to the CAM, the program manager will also be able to receive even further insight of any possible issues with the program.

He uses an analogy of a car: “if our car would not start, we would focus on repairs at the lower-level starter system and not on analysis at the overall car level or unrelated lower-level areas such as paint, tires, or structure” (Bushey, 2007). However, in his research, he states the benefits of lower level data, but fails to show a quantitative supporting argument for his statement.

Fonnesbeck and Lee conducted a study in 1987. In their research, the authors were looking at the WBS from a cost estimator’s perspective. They wanted to be able to deliver the best cost estimate with the cost data available. One of the problems they stated was the lack of standardization of cost data below level three. The main reason they state this requirement will not change is:

> the Office of Management and Budget (OMB) has established guidelines requiring OSD to minimize the reporting requirements placed on the contractors by the CCDR system. This seems to concur with the administration policy to reduce the volume of bureaucratic paperwork.

The authors interviewed different DoD contractors while conducting this study. The authors' intent was to determine if the contractors could provide cost data lower than level three of the WBS. They found most contractors had cost data at least one level below the PWBS and some had data as low as levels eight and nine. Fonnesbeck and Lee gave two suggestions on how to improve cost report, even if we cannot change the requirement for contractors to only report down to level three. One of their suggestions dealt with creating a time-phased data reporting system and a data base system to store EVM data. The other suggestion, however, is to remove some level three elements and replace them with their level four sub-elements. This sounds simple, but the authors found in many projects that the level four element could account for more than 40% of the level two element above it. By not being able to track the level four element closely, it makes reporting where a problem is more difficult, if not impossible (Fonnesbeck and Lee, 1987).

Conclusion

In the chapter, we provided a brief look into how a WBS works and the relationships between the CWBS and the PWBS. We also explained the definition of earned value with some basic formulas and definitions. Then, we went over the history and evolution of earned value in the DoD. Through our research, we have not seen any research looking into the exact problem we are researching. However, Rosado, Etxegoien, Bushey, Fonnesbeck and Lee demonstrate there have been some studies

completed on this topic, but these authors lacked the ability to obtain cost data down to the control account level. In the next chapter, we will explain our data collection process and methodology for evaluating our cost data in detail.

Chapter 3 – Data Collection and Methodology

Chapter Overview

This chapter describes our data collection and methodology in our research. The objective of this chapter is to make clear the steps we performed in our analysis and data collection and give the reason behind our choices. We also briefly explain other techniques we attempted, as well as the analysis and the reason we chose not to use them. By the end of this chapter, we will have shown you how we collected our data and how we limited it. We will also have shown our criteria for evaluating our research question and the steps we took to obtain our results.

Defense Cost and Resource Center (DCARC)

History and Intent

Established in 1998, DCARC's primary role is to collect past and present Major Defense Acquisition Programs in one central location. DCARC has four main objectives. The first is to allow one location to collect contractor's cost and software data reports. The second allows authorized users access to this cost data for analysis for future projects. The third objective is to maintain the integrity and accuracy of the data collected from contractors. The final object is to improve the quality of data reported by industry. The overall goal of DCARC is to provide senior leaders with accurate and timely cost estimates in order to provide the war fighter the weapons and equipment needed to win (DCARC, 2007).

Earned Value Management Central Repository

We collected the data for our research from the Earned Value Management Central Repository (EVM-CR) found on the Defense Cost and Resource Center (DCARC) portal. Designating a single place where contractors can submit their Contract Performance Reports (CPRs), Contract Funds Status Reports (CFSRs), and Integrated Master Schedules (IMSs) is the function of the EVM-CR (Office of the Secretary of Defense Central Repository for Earned Value Management (EVM) Data Manual, 2008). Performance Assessments and Root Cause Analysis (PARCA) directly oversees EVM-CR.

A contractor must submit seven different CPRs. Contractors have used the first five formats for years. However, in 2012, formats six and seven were established (PARCA Memo, 2012). The intent of these two new formats is to better integrate cost and schedule reporting. Format six contains the contract's Integrated Master Schedule (IMS) and format seven contains an electronic history and forecast file. The format we will focus on in our research is format seven.

The EVM-CR sorts all of the programs into five different organizations. The five organizations are Army, Air Force, Navy, Department of Defense, and Missile Defense Agency (MDA). There are currently 143 different programs and 422 contracts found on the EVM-CR. Table 3 displays the breakdown by organization.

Table 3 - EVM-CR Program Breakdown

	# of Programs	# of Contracts
Army	34	74
Air Force	40	93
Navy	46	181
DOD	12	50
MDA	11	24
Total	143	422

Data Collection

In this section, we will explain the process and steps required to create our data set and subsequently use in our evaluation of our research questions. The first step implemented was to request access to the EVM-CR database through PARCA for approval. Initially, we only had access granted to the Army's EVM data. This restriction was due to policies at PARCA limiting access only to the service of the requesters. In order to gain access to the Navy's and the Air Forces' EVM data, we had to submit an exception to the policy and then each branch's representative had to approve our request. Ultimately, the Army, Air Force and Navy cost data were the only agencies we had permission to access. Both the Missile Defense Agency and DoD projects did not grant access. However, we felt the three services we had would provide sufficient data to conduct our research.

Selecting Contract Data

Once we had access to the EVM data, we determined the criteria we needed in order to answer our research questions. We looked through every contract (to date) for

the Army, Air Force and Navy. The first and most important requirement was that the contract had to have EVM data down to at least level five of the WBS. We also needed to ensure that the level five EVM data was different from the level three data. In many of the contracts, we found level three and five data identical. In these cases, we removed those elements from our analysis.

Our second criterion was that each contract has at least twelve consecutive periods of EVM data. The reason for the requirement was to allow us to analyze our explanatory variable over a length of time. We determined any contract with less than twelve periods of EVM data would limit the predictive capabilities of our model.

Our final criterion was that the data was complete and relevant. The system was able to tell us if the contractor had lower level data and if the contract was over twelve months, however, the system could not tell us if the data was complete or if all the months had EVM data. In our screening of these criteria, we found that many elements reported by the contractor failed to have complete EVM data. Many times contractors would only report their Latest Revised Estimate (LRE). We also found in some contracts, the contractor left multiple months of EVM data empty.

Contract Selection Criteria

After we determined the criteria for our data, we needed to create requirements for the individual contract in the EVM-CR. The EVM-CR database organizes its EVM data into six different types of files. They are Integrated Program Management Report (IPMR) Cost, Formatted Cost, IPMR Schedule, Native Schedule, Contract Fund Status Report (CFSR), and History files (Format 7). However, we found the best way to obtain our data was by looking only for history files. The history file presented each of the

WBS elements and their cumulative changes over the length of the project. Contracts are required to upload a new history file to the EVM-CR at least annually. In cases where there were more than one history file with a contract, we only downloaded the most recent published history file.

In order to view and sort the history files we downloaded, we used the CPR File Viewer software provided from the DCARC website. This software allowed us to quickly sort and evaluate the different contracts. Once we sorted the contracts, we used the software to download the files into Microsoft Excel format. We then used these Excel files to define our explanatory variables to use in our statistical analysis.

Overview of Data

After applying our data and contract criteria, we narrowed the number of contracts from 422 to 40. Appendix B contains a list of the forty contracts. Table 4 illustrates the breakdown by criteria. Column 1 and 2 indicate the number of programs and contracts in each service. The following four columns are the criteria for limiting data. The numbers in Table 4 are dependent on the number to the left. An example, the Army had thirty contracts with at least level five data and only twenty-five of them were greater than twelve months. The final column calculates the percentage of contracts with usable data.

Table 4 - Data Overview by Criteria

<table>
<tr><th></th><th># of Programs</th><th># of Contracts</th><th># with History Files</th><th>Lvl 5 or greater WBS</th><th>>12 Months</th><th>Complete Data</th><th>% Complete</th></tr>
<tr><td>Army</td><td>34</td><td>74</td><td>52</td><td>30</td><td>25</td><td>9</td><td>12.16%</td></tr>
<tr><td>Air Force</td><td>40</td><td>93</td><td>54</td><td>24</td><td>18</td><td>4</td><td>4.30%</td></tr>
<tr><td>Navy</td><td>46</td><td>181</td><td>111</td><td>44</td><td>30</td><td>27</td><td>14.92%</td></tr>
<tr><td>DOD</td><td>12</td><td>50</td><td>21</td><td colspan="4" rowspan="2">ACCESS NOT GRANTED</td></tr>
<tr><td>MDA</td><td>11</td><td>24</td><td>6</td></tr>
<tr><td>Total</td><td>143</td><td>422</td><td>244</td><td>98</td><td>73</td><td>40</td><td>9.48%</td></tr>
</table>

From looking at Table 4, we can identify the breakdown of the forty contracts by department. We also see a majority of the contracts came from Navy contracts. Furthermore, Table 4 makes evident the Air Force has the smallest percentage of usable contracts.

Observing just the forty contracts used in our analysis, we broke the contracts down by which phase the contract was in (RDT&E, Production, Other or Unknown), ACAT level (IAC, IAM, IC, ID, II, III or Unknown), contract type (CPAF, CPFF, CPIF, FFP, or IDIQ) and type of WBS (Aircraft, Electronic/Automated Software, Missile, Ordnance, Ship, Space, UAV or Other). Table 5 illustrates the breakdown by phase of contract.

Table 5 - Data by Phase

<table>
<tr><th></th><th># of Programs</th><th># of Contracts</th><th># with History Files</th><th>SDD</th><th>Prod</th><th>Other</th><th>Service</th><th>Unknown</th></tr>
<tr><td>Army</td><td>34</td><td>74</td><td>46</td><td>5</td><td>3</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Air Force</td><td>40</td><td>93</td><td>49</td><td>3</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Navy</td><td>46</td><td>181</td><td>104</td><td>14</td><td>9</td><td>1</td><td>0</td><td>3</td></tr>
<tr><td>DOD</td><td>12</td><td>50</td><td>16</td><td colspan="5" rowspan="2">ACCESS NOT GRANTED</td></tr>
<tr><td>MDA</td><td>11</td><td>24</td><td>3</td></tr>
<tr><td>Total</td><td>143</td><td>422</td><td>218</td><td>22</td><td>13</td><td>1</td><td>0</td><td>4</td></tr>
</table>

As Table 5 displays, all but five of the contracts are either RDT&E or Productions contracts.

Table 6 illustrates the breakdown by ACAT.

Table 6 - Data by ACAT

	# of Programs	# of Contracts	Complete Data	IAC	IAM	IC	ID	II	III	Unknown
Army	34	74	9	0	0	3	5	0	0	1
Air Force	40	93	4	1	1	0	1	0	1	0
Navy	46	181	27	0	0	12	15	0	0	0
DOD	12	50	ACCESS NOT GRANTED							
MDA	11	24								
Total	143	422	40	1	1	15	21	0	1	1

Table 7 indicates the breakdown by contract type

Table 7 - Data by Contract Type

	# of Programs	# of Contracts	Complete Data	CPAF	CPFF	CPIF	FFP	FPIF	IDIQ
Army	34	74	9	1	1	4	2	1	0
Air Force	40	93	4	1	1	0	1	0	1
Navy	46	181	27	11	5	6	0	4	1
DOD	12	50	ACCESS NOT GRANTED						
MDA	11	24							
Total	143	422	40	13	7	10	3	5	2

Table 8 illustrates the data by type of WBS.

Table 8 - Data by type of WBS

	# of Programs	# of Contracts	Complete Data	Aircraft	ELECTRONIC/ AUTOMATED SOFTWARE	Missile	Ordance	Ship	Space	UAV	Other
Army	34	74	9	0	4	1	2	0	0	0	2
Air Force	40	93	4	1	2	0	0	0	1	0	0
Navy	46	181	27	10	5	4	0	5	0	3	0
DOD	12	50		**ACCESS NOT GRANTED**							
MDA	11	24									
Total	143	422	40	11	11	5	2	5	1	3	2

Table 9 lists each of the forty contracts and the total number of level five elements in the contract. Table 9 also breaks down the size of the level five elements as a percentage of the level one EAC.

Table 9 - Total number of level 5 Elements

	Total # of lvl 5	# lvl 5 w/ EVM data	>.25%	>.50%	>1%
B2 MOP - Massive Ordance Penetrator (F33657-99-D-0028)	126	66	17	9	7
Chem Demil - CMA (DAAA09-97-C-0025)	2494	1520	63	19	9
Chem Demil - CMA (DACA87-89-C-0076)	441	293	41	30	20
Excalibur (DAAE30-98-C-1032)	23	21	20	18	15
Excalibur (W15QKN-08-C-0530)	22	20	20	20	16
FBCB2 (W15P7T-04-D-G205)	443	300	96	53	18
IAMD (W31P4Q-08-C-0418)	495	345	83	48	19
ISPAN (FA8722-04-C-0009)	141	104	65	40	29
JAGM (W31P4Q-08-C-A123)	34	33	25	23	21
JTRS (DAAB07-02-C-C403)	29	24	7	4	1
MPS - SEIC (FA8720-05-C-0005)	54	28	25	23	15
NAVSTAR GPS (FA8807-06-C-0001)	302	160	31	14	10
WGS (FA8808-06-C-0001)	54	21	20	20	15
WIN-T INC3 (DAAB07-02-C-F404)	75	68	37	31	15
AAG - Advanced Arresting Gear Program (N68335-03-C-0205)	608	419	101	60	19
AGM-88E (Advanced Anti-Radiation Guided Missile (N00019-03-C-0353)	96	78	39	27	17
AIM-9X Block II (N00019-12-C-2002)	48	25	22	16	14
AMDR - Air & Missile Defense Radar (N00024-10-C-5359)	33	17	13	13	10
CEC - Cooperative Engagement Capability (N00024-05-C-5100)	104	73	45	33	22
DDG 1000 - Zumwalt Class Destroyer (N00024-05-C-5346)	3820	2746	69	31	7
DDG51 - Arleigh Burke Class Guided Missile Destroyer (N00024-02-C-2304)	27	21	16	15	12
EA-18G - Airborne Electronic Attack variant (N00019-04-C-0005)	10	7	3	3	2
H1 Upgrades (N00019-06-G-0001)	28	23	12	12	6
JPALS - Joint Precision Approach and Landing System (N00019-08-C-0034)	178	109	36	28	15
JPALS - Joint Precision Approach and Landing System (N00019-08-C-0034) (2)	49	41	32	21	15
JSOW (N00019-05-G-008-DO)	12	12	10	10	9
LCS - Littoral Combat Ship (N00024-03-C-2310)	1729	524	38	28	21
LCS - Littoral Combat Ship (N00024-11-C-2301)	87	32	18	17	15
LPD 17 - San Antonip Class (N00024-04-C-2204)	2193	308	47	27	14
MH-60R (N00019-04-C-0130)	50	47	33	28	22
MH-60R (N00019-08-C-0005)	53	48	32	27	23
MH-60R (N00019-09-C-0059)	24	18	12	12	10
MH-60S (N00019-03-C-0003)	101	80	43	33	17
MQ-4C Triton (N00019-08-C-0023)	772	523	51	24	11
P-8A Poseidon Program (N00019-04-C-3146)	38	24	14	12	9
SM-6 Standard Millile 6 (N00024-04-C-5344)	104	100	61	37	22
SM-6 Standard Millile 6 (N00024-09-C-5305)	81	77	37	24	18
V-22 - Osprey Joint Advanced Vertical Aircraft (N00421-10-D-0012)	4	4	4	4	3
V-22 - Osprey Joint Advanced Vertical Aircraft (N61339-08-D-0004)	36	23	10	7	5
V-22 - Osprey Joint Advanced Vertical Aircraft (N61340-11-C-0004)	17	11	9	8	7
VTUAV (N00019-00-C-0277)	204	157	52	29	16
VTUAV (N00019-12-C-0059)	725	429	58	25	10
Number of Level 5 elements	15964	8979	1467	963	581
Percent of total # level 5		56.25%	9.19%	6.03%	3.64%

Table 9 reveals that 56.25% of all the level five elements actually had EVM data. In addition, we can see that less than 10% of all the level five elements are larger than 0.25% of the total contract.

Contract Error

While going through the forty contracts, we found numerous errors within the contracts. Although these errors did not seem intentional, we needed to address the errors the best we could. We either removed the WBS element from the calculations or attempted to reconstruct the intended value. Some examples of attempting to reconstruct the intended value are when the WBS element is on a constant growth and then a month is blank. After which, the WBS element continues to grow at the previous growth rate. Table 10 notionally demonstrates this error.

Table 10 – Notional Example #1 of Contract Errors

	Time					
	1	2	3	4	5	6
WBS Element	$5	$10	$15		$25	$30

In this insistence, we would extrapolate the EVM values for the missing month. In this example, we would have inserted $20 in the fourth month. Table 11 illustrates another common error we encountered. In this type of error, a contractor inserted a monthly change instead of the cumulative change for a WBS element.

Table 11 – Notional Example #2 of Contract Error

	Time					
	1	2	3	4	5	6
WBS Element	$10	$20	$30	**$10**	$50	$60

In this insistence, we would add the monthly change value to the last reported cumulative value. In this example, we would have inserted $40 in the fourth month. ACWP, BCWP, and BCWS were common places we found this type of error because of the constant growth of these elements. We found 212 errors in twenty of our forty contracts. Table 12 details the twenty contracts with errors and the number of errors in each contract.

Table 12 - Number of Errors per Contract

Service	Project Name	Prime Contract Number	# of errors within contract Level 3	# of errors within contract Level 5
Air Force	B-2 MOP - Massive Ordnance Penetrator	F33657-99-D-0028	0	1
Navy	CEC – Cooperative Engagement Capability	N00024-05-C-5100	1	50
Army	Chem Demil - CMA	DACA87-89-C-0076	0	1
Army	Chem Demil - CMA	DAAA09-97-C-0025	1	2
Navy	DDG 1000 - ZUMWALT CLASS Destroyer	N00024-05-C-5346	0	1
Army	IAMD - Integrated Air & Missile Defense	W31P4Q-08-C-0418	0	2
Navy	LCS - Littoral Combat Ship	N00024-11-C-2301	20	0
Navy	LPD 17 - SAN ANTONIO CLASS Amphibious Transport Dock Ship	N00024-04-C-2204	0	6
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-09-C-0059	0	3
Navy	MH-60S - Multi-Mission Combat Support Helicopter	N00019-03-G-0003	0	10
Navy	MQ-4C Triton (Formerly BAMS)	N00019-08-C-0023	0	12
Navy	P-8A - Poseidon Program	N00019-04-C-3146	0	11
Navy	SM-6 – Standard Missile-6	N00024-04-C-5344	0	5
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012	0	1
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61340-11-C-0004	0	7
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61339-08-D-0004	1	1
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-00-C-0277	0	46
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-12-C-0059	0	26
Air Force	WGS – Wideband Global SATCOM Program	FA8808-06-C-0001	0	3
Army	WIN-T Inc. 3 - Warfighter Information Network Tactical Increment 3	DAAB07-02-C-F404	0	1

Table 12 indicates 89% of the errors we detected were in level five elements.

Methodology

EAC Growth

We decided to use the EAC growth as our predictive variable. The main reason we decided to use EAC as our predictive variable is because EAC allows us to project where the contract's final cost is heading. The issue we found with using the EAC is what value do we use? For each element, the contractor provides an EAC. However, the usage of the formulas stated in Chapter Two cannot calculate the contractor's EAC. In most cases, contractors provide their latest revised estimate (LRE) as the EAC instead of using an established formula. The contractor's LRE is their estimation of future cost for the element. It can include factors outside of EVM data. This caused an issue with our research in determining the predictive capabilities of the lower level earned value data. In the next section, we will discuss the way we decided to calculate the EAC. As stated in Chapter Two, there are many different ways EAC can be calculated using earned value data.

Defining Percent EAC Growth

First, we had to determine how we would calculate our EAC. As stated earlier, the EAC provided by the contractor in the EVM data was actually the contractor's LRE. However, the LRE is very subjective and we decided not to only use this value for our EAC. We decided to also use the composite EAC as discussed in Chapter Two. The reason we chose this formula is that it is the most conservative formula for the EAC. Below is the formula for the $EAC_{composite}$:

$$EAC_{Composite} = AC + [BAC - EV] / [CPI * SPI]$$

We were able to calculate the EAC composite using the EVM data provided by the contractor from the EVM-CR. We then recalculated all the monthly EACs for each element at level one, three and five.

Defining Lower Level EAC Growth

We evaluated two different techniques to measure levels three and five cost growth. The first method examined only the cost growth of the individual elements within each level. Definitions #1 and #2 used this technique. The second technique examines the overall cost growth within a level. We used this technique with definitions #3 and #4. Additionally, the second technique is the method Rosado used in his research. Figure 8 displays each of the four definitions and if it used the EAC or LRE and which cost growth technique was used. The next section explains each of these definitions further.

EAC **Cum Change** **Definition #3**	**EAC** **Element Change** **Definition #1**
LRE **Cum Change** **Definition #4**	**LRE** **Element Change** **Definition #2**

Figure 8 - EAC Growth Definitions

Explanatory Variables

Once we recalculated our predictive variable, EAC growth, we created our level three and five explanatory variables to use in our different statistical models. We used

the four definitions in Figure 8 for both our level three and five variables. Figure 9 illustrates each definition. In all four instances, we created a ratio by dividing the monthly change of our predictive variable by the last reported level one EAC. By creating a ratio, in respects to the final level one EAC, it allowed us to normalize our data.

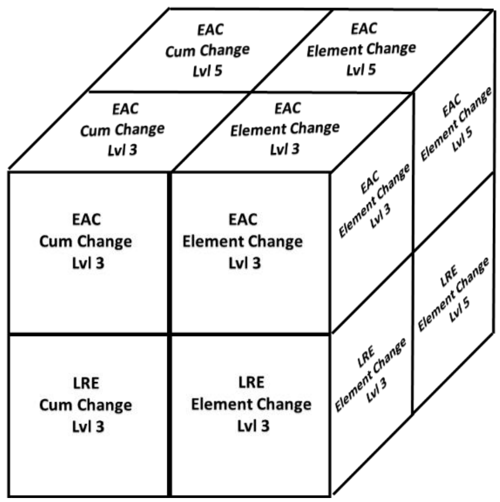


Figure 9 - Level three and Five Explanatory Variables

<u>Cost Growth Definition #1</u>

In most cases, not all level three or five elements start at the beginning of the contract. Our first definition looked only at the cumulative change in each level's EAC. This method excluded the initial cost of an element. Table 13 displays this example. This method allowed us to compare only the cost growth of lower level elements.

Table 13 – Cost Growth Definition #1 Example

		Time				
		1	2	3	4	5
Element	1	$10	$15	$20	$25	$30
	2		$10	$10	$10	$15
	3				$50	$100
Monthly Change		$0	$5	$5	$5	$60
Cum Change		$0	$5	$10	$15	$75

Cost Growth Definition #2

With the exception of the usage of the contractor's EAC provided in the contract, the calculated variable used the same technique as definition #1. This allowed us to evaluate if there was a difference using the contractor's EAC or recalculating the EAC using an established formula.

Cost Growth Definition #3

Similar to the first definition, this looked at our recalculated EAC. Definition #3 differs from the first by including the cost of new elements into our calculations of the monthly cumulative change. Table 14 illustrates this example.

Table 14 – Cost Growth Definition #3 Example

		Time				
		1	2	3	4	5
Element	1	$10	$15	$20	$25	$30
	2		$10	$10	$10	$15
	3				$50	$60
Monthly Change		$10	$15	$5	$55	$60
Cum Change		$10	$25	$30	$85	$145

Cost Growth Definition # 4

Definition #4 is another test variable using the same technique as definition #3, except the contractors EAC. Again, for this definition, we created it to compare a recalculated EAC with the contractor's provided EAC (LRE).

Normalizing Cost Growth

Our contracts ranged in value from $19 million to over five billion dollars. In order to compare the wide range of data, we created a cost growth ratio for each of our eight explanatory variables. Our ratio compares the cumulative change divided by the final level one EAC.

$$Cost\ Growth\ Ratio\ = \frac{Level\ 3\ or\ 5\ Cum\ Change}{Final\ Level\ 1\ EAC\ (or\ LRE)}$$

Normalizing Contract Length

Our contracts ranged from twelve months to over eighty months. In order to compare this wide range of data, we calculated the percent complete of level one for each month of the contract. The formula we used to calculate the percent complete was (Tracy, 2005):

$$Percent\ Complete = CumBCWS/BAC$$

Upon completion of the percent complete calculation for each month, we created bins for every 5% complete. A bin would contain any month falling within plus or minus 2.5% of the bin value. For example, the 40% complete bin would contain any month with a percent complete greater than or equal to 37.5% and less than 42.5%. In cases where more than one month fell into a bin, we used only the last month that fall within the bin.

Multiple Regression

The technique we used in our analysis was Ordinary Least Squared (OLS) multiple regression. We used OLS multiple regression to create and analyze our four different definitions of cost growth. There were three main reasons why we chose this method. The first reason for choosing OLS multiple regression was to evaluate the overall model using the F-test. We then compared the F-test value to our alpha (.05). The model failed if the F-test's p-value was greater than the alpha. The second reason we chose this method was that it provided a T-test. The T-test evaluates each individual independent variable. We used Bonferroni correction to determine if each independent variable was significant. Bonferroni correction compares the independent variable's p-value to our alpha (.05) divided by the number of independent variables in the model. An example using Bonferroni correction is if there are five independent variables then for the variable to be significant, its p-value needs to be less than 0.01 (0.05 divided by five). The final analysis this method provided was a variance inflation factor (VIF) score. The VIF score quantifies the magnitude of multicollinearity of the independent variables in the regression model. In order to determine if two or more independent variables correlated, we ensured that each variables VIF score was less than five. Any value over five meant that the particular variable had a higher than acceptable amount of correlation with at least one other variable.

We also used stepwise regression to determine which independent variables were included in our models. Stepwise regression is an automatic process conducted by our statistical software. The software adds or removes variables attempting to create the most predictive model available with the independent variables available. We used stepwise

regression to determine our variables because in each of our models we had our level three and five explanatory variables along with over fifty independent variables. Appendix C contains a list of all the independent variables used in our models. Since we were not sure which variables would be the most predictive, we used stepwise regression to determine which ones to add.

The final tool we used with our multiple regression was Cook's Distance or Cook's D. Cook's D allowed us to determine if a certain contract was overly influential in our regression output. We defined a contract as being overly influential if its Cook's D score was greater than 0.5.

Fit Y by X

We also evaluated the relationship between our level three and five EVM data. We used a fit Y by X to examine this relationship. The fit Y by X compares the relationship between one independent variable and the response variable. We identified our level three variable as the response variable and the level five variable as our explanatory variable. This technique allowed us to compare our level three and our level five data to detect any correlation between the level three and five variables. We used this technique for definitions #3 and #4 at each 5% complete bin. This technique allowed us to compare the slope of the fit line to determine the relationship between level three and five. A slope of one would indicate there is perfect correlation between level three and level five data.

The software package we used in our analysis was JMP® 11.0. There were two reasons we chose this software. First, JMP® was able to perform all the different types of analysis we required and could handle the amount of variables we needed to include. The

other reason we chose JMP® was our familiarity with the software. Key elements for choosing the software were due to prior knowledge of the software, wide availability and its capabilities.

Conclusion

In this chapter, we described our data collection methods. We also created criteria for the contracts, as well as for the data within the contracts. We described our data set and explained our methodology to answer our research questions. In the next chapter, we review the results of our data in the different statistical models described.

Chapter 4 – Analysis and Results

Chapter Overview

We created a regression model, which would determine if level five EVM data was more predictive than level three EVM data. We anticipated the ability to indicate level five data, compared to level three data, was a better predictor for overall cost growth.

We measured overall cost growth by calculating the growth of level one's EAC from the first reported period to the final period. Given our data set, our regression model includes service, program type, contractor and length of contract. In order to compare the contractor's provided EAC with an EVM calculated EAC, we divided Chapter Four into two sections. For the purpose of the rest of this chapter, we will refer to the contractor's EAC as an LRE and the recalculated EAC as the EAC.

The first section evaluates the EAC, while the second section will evaluate the LRE. Each of these sections has the same structure. First they will examine the distribution of our response variable (percent increase in level one EAC (or LRE)) and identify any outlier contracts. Then, they both display the multiple regression results. The results also display any contracts excluded either because it was an extreme outlier or was overly influential in the model.

Evaluating the EAC

In the following sections, we examine the results using the EAC.

Distribution of Response Variable

While conducting our analysis, we detected two extreme outlier contracts based upon level one recalculated EAC growth. Contract N00019-06-G-0001 and W15P7T-04-D-G205 grew 11,606% and 1,405% respectively. Figure 10 displays the distribution of the percent change in level one's EAC.

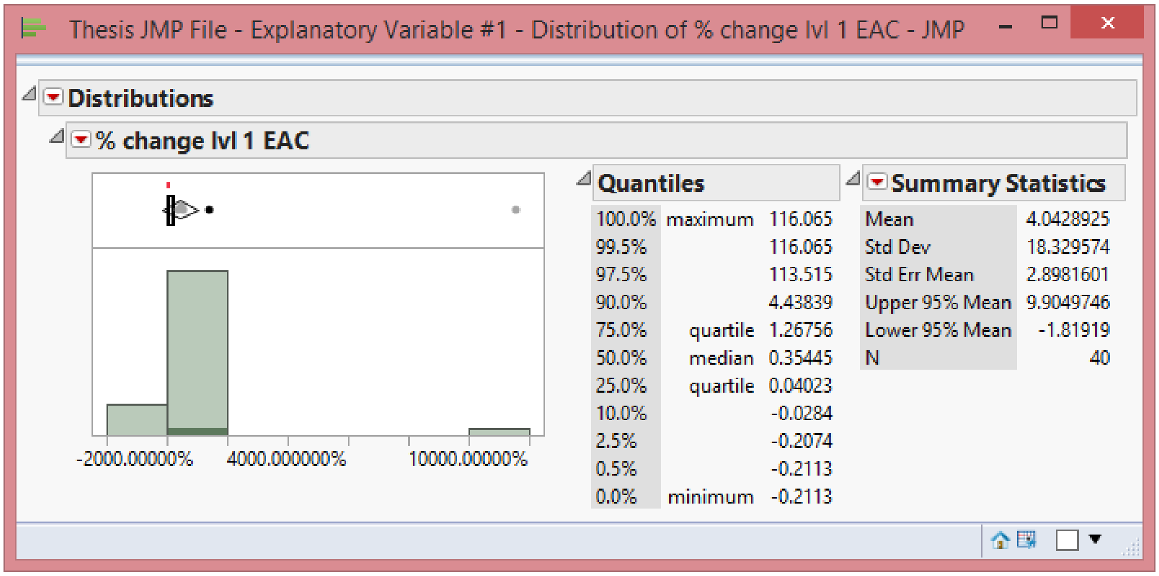


Figure 10 - Distribution of Percent Change of Level 1 EAC

We removed these two contracts from our data set. This lowered our total number of contracts for our analysis down to thirty-nine. Figure 11 represents the distribution excluding the two contracts.

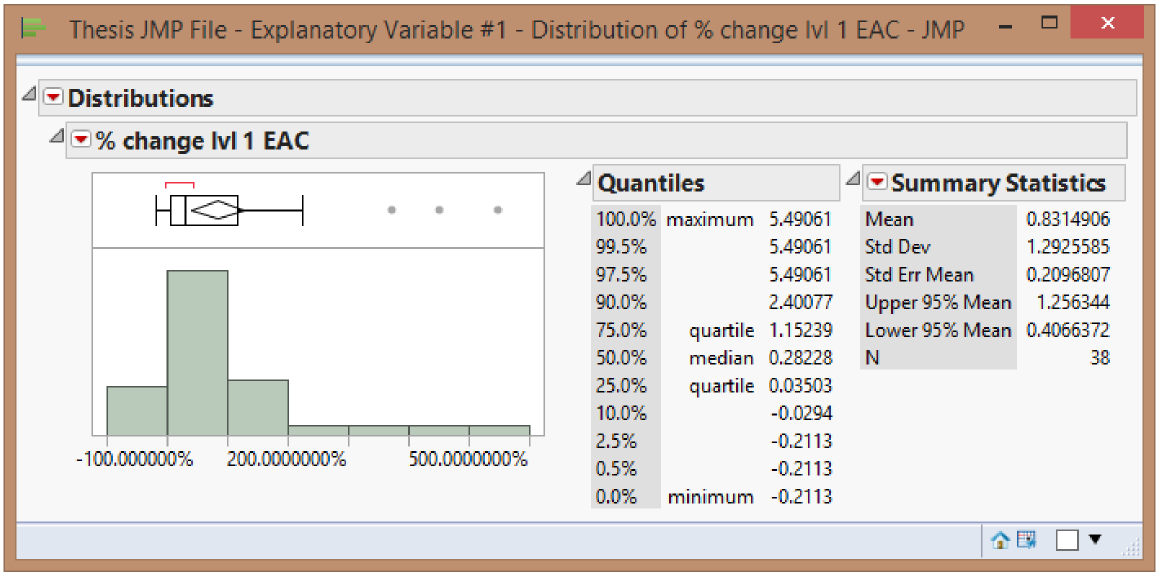


Figure 11 - Distribution of Percent Change of level 1 EAC (excluding two extreme outliers)

After removing the two extreme outliers, three additional contracts became outliers. Figure 12 displays our distribution removing these additional three outlier contracts.

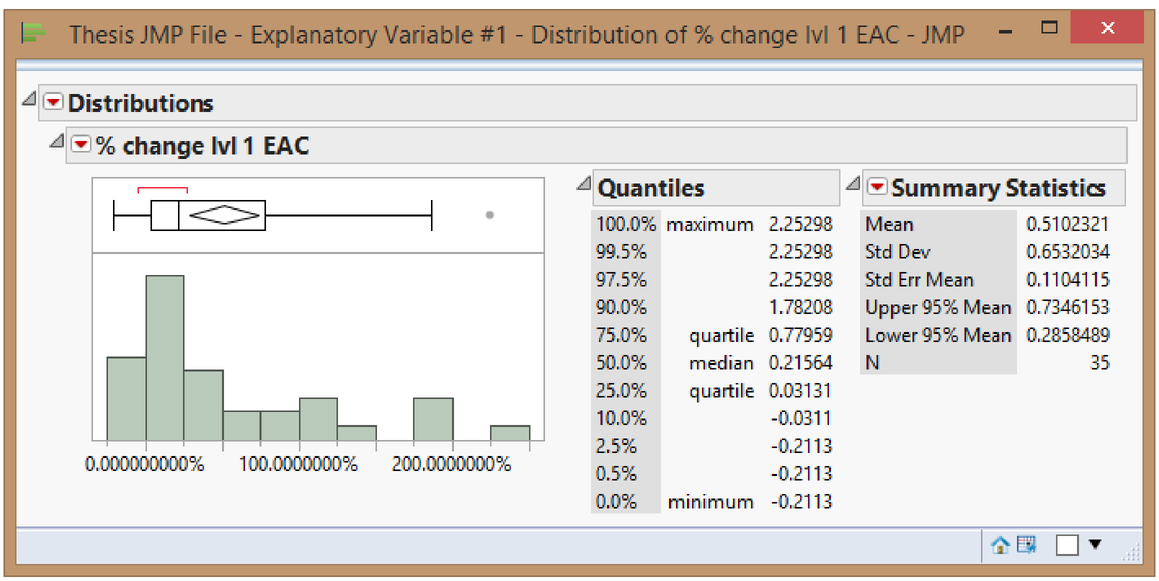


Figure 12 - Distribution of Percent Change of level 1 EAC (excluding three additional outliers)

After removing the three additional outliers, one additional outlier was recognized and removed.

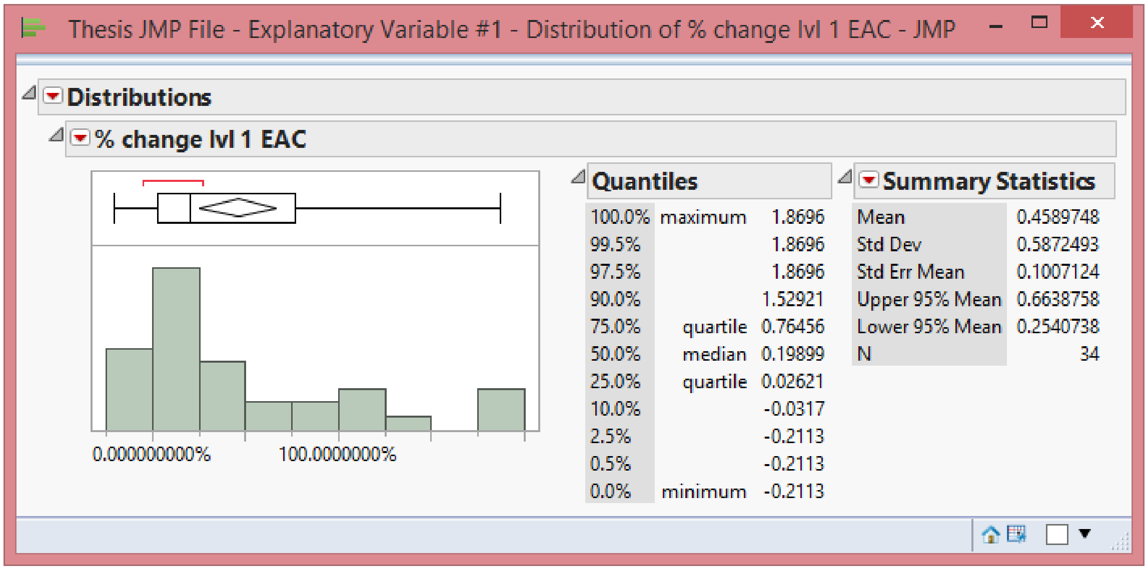


Figure 13 - Distribution of Percent Change of level 1 EAC (excluding all outliers)

Figure 13 displays the distribution of the response variable excluding all outliers. By excluding these six contracts, it lowered our mean EAC growth from 404% to 46% and lowered the standard deviation from 1832% to 59%. We identified six outliers, however, within our models we initially only excluded the two extreme outliers. Table 15 details the six outlier contracts and the percent change in level one EAC.

Table 15 – EAC Contract Outliers

% change lvl 1 EAC	Service	Project Name	Prime Contract Number
11606.53%	Navy	H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter	N00019-06-G-0001
1405.37%	Army	FBCB2 - Force XXI Battle Command Brigade and Below Program	W15P7T-04-D-G205
549.06%	Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-12-C-0059
451.70%	Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012
373.09%	Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61340-11-C-0004
225.30%	Air Force	ISPAN - Integrated Strategic Planning and Analysis Network - Block 1	FA8722-04-C-0009

The first two contracts in Table 15 are the two extreme outliers, while the next four were the subsequent outliers. Next, we briefly explain each outlier.

The H1 upgrade was the most extreme outlier in our data set. Figure 14 displays the contract's EAC along with the BAC. There are two reasons for the large percent increase in level one EAC. The first reason was because its first EAC and BAC were extremely low. The initial EAC was $702,478 and the initial BAC was $1,375,089. Two months later, both of these figures increased to $27,591,793 and $19,151,617 respectively. Figure 14 also identifies a change in scope in October 2009, which is another cause for the increase in cost.

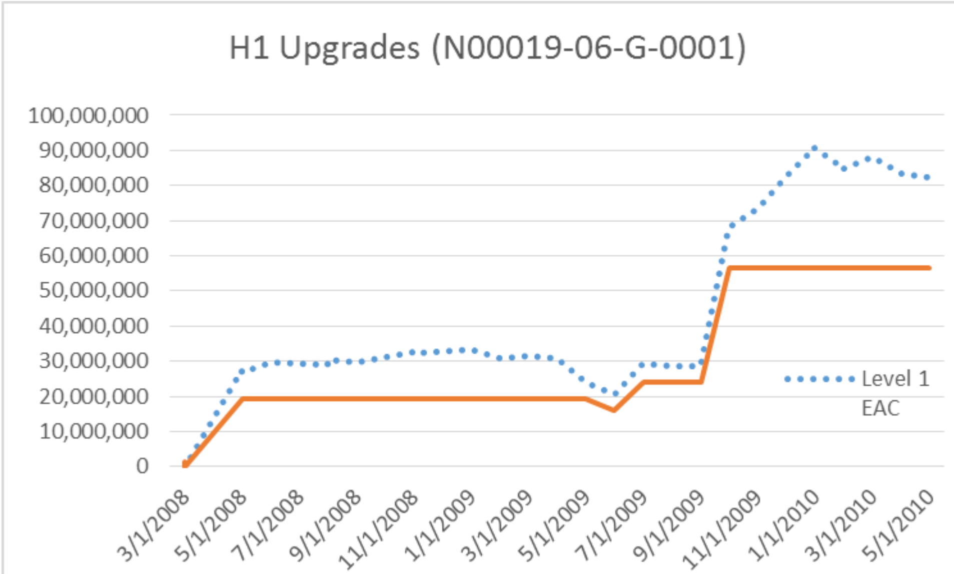


Figure 14 - H1 Upgrade

The next contract excluded was the FBCB2. Figure 15 displays both the EAC and BAC for this contract. Unlike the H1 upgrade, a constant change in quantity ordered caused this contract's cost growth. This contract's cost has been increasing at a constant rate since it began.

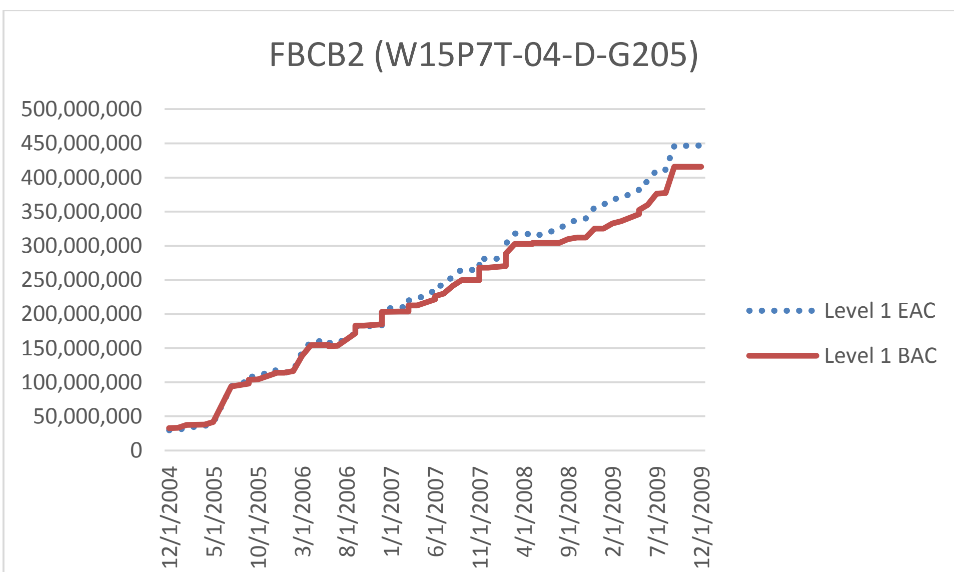


Figure 15 - FBCB2

Excluding one of the Navy's VTUAV contracts, Figure 16 displays both the EAC and BAC. An early change in scope and/or additional requirements explains the reason for the cost growth in this contract.

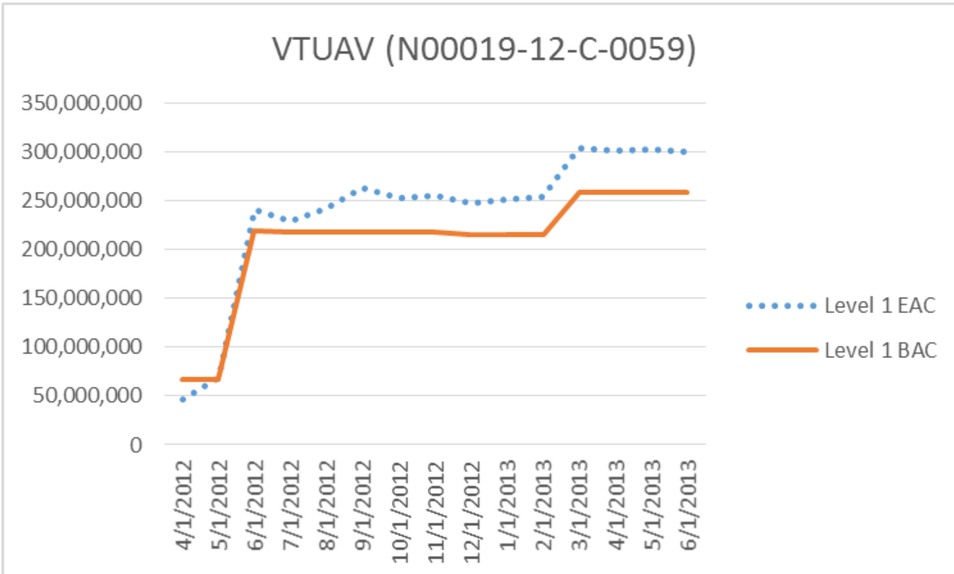


Figure 16 - VTUAV (N00019-12-C-0059)

The next two contracts excluded came from the V-22 OSPREY program. The first V-22 contract appears to have had cost overruns since the contract began.

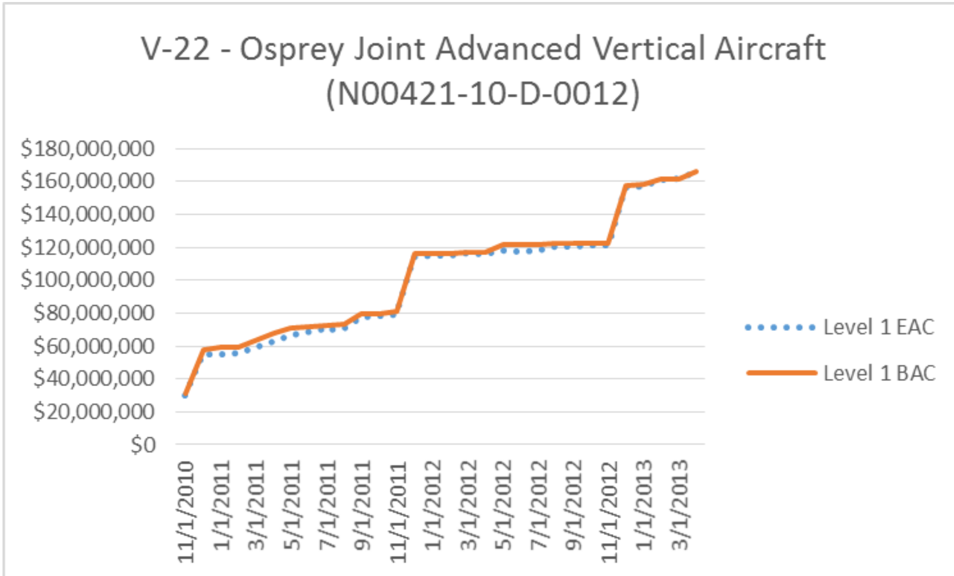


Figure 17 - V-22 - Osprey Joint Advanced Vertical Aircraft (N00421-10-D-0012)

The second V-22 contract shows a large growth in EAC due to the EVM data inputted the first month. However, we did not remove the first month's data because we wanted to compare the EVM data.

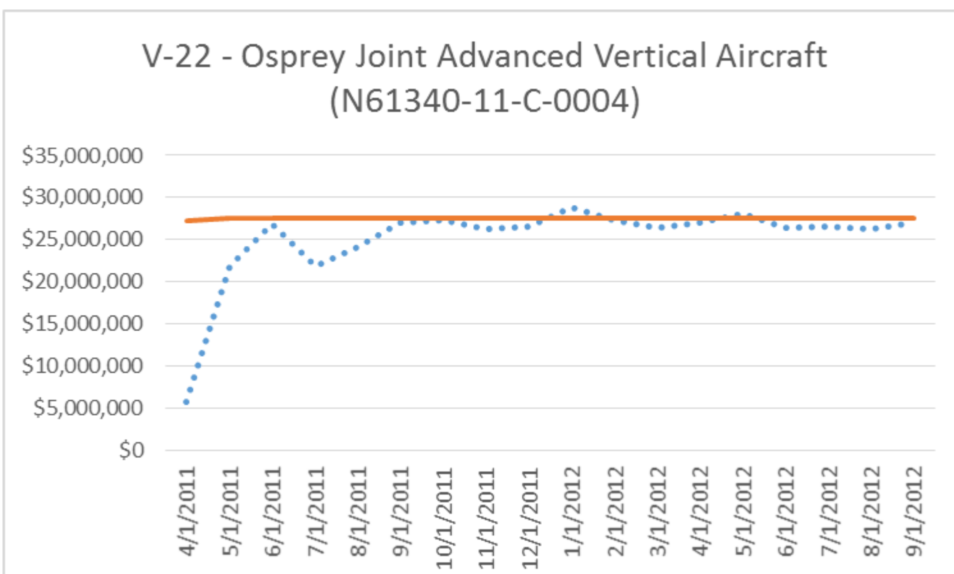


Figure 18 - V-22 - Osprey Joint Advanced Vertical Aircraft (N61340-11-C-0004)

The final contract excluded was the ISPAN contract. This contract, similar to the FBCB2 contract, has had a constant cost growth since the beginning of the contract.

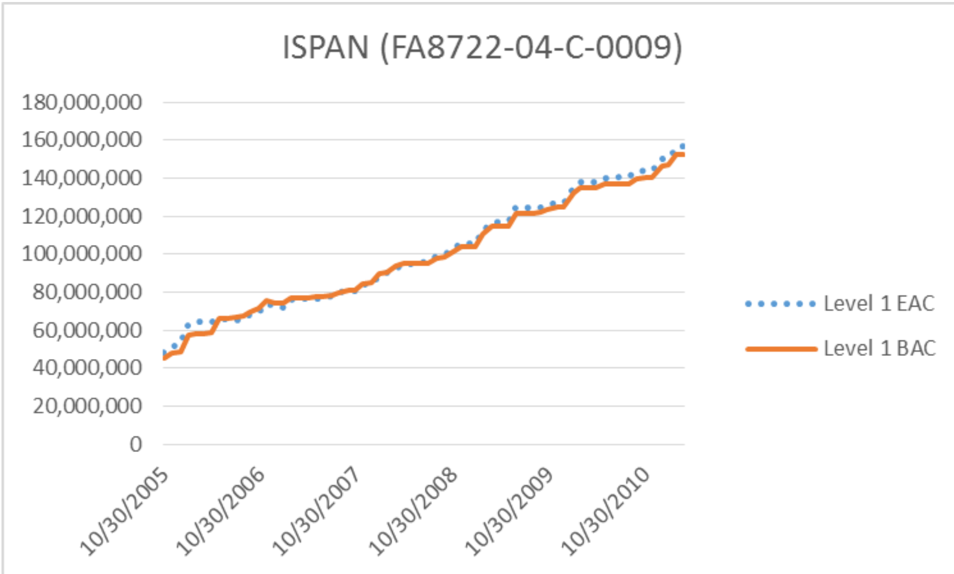


Figure 19 - ISPAN (FA8722-04-C-0009)

<u>Multiple Regression Results using EAC</u>

For each definition, we created a twenty multiple regression models, one for every 5% complete, starting at 5% and ending at 100%. Figure 20 displays the regression equation for growth definitions #1 and #2. Figure 21 displays the regression equation for growth definitions #3 and #4. Figure 22, illustrates how many contracts had cost data in each percent complete bin.

$$E(y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

Definition #1

Y = *Level 1 EAC Change*

X_1 = *Level 3 Explanatory Variable*

X_2 = *Level 5 Explanatory Variable*

Definition #2

Y = *Level 1 LRE Change*

X_1 = *Level 3 Explanatory Variable*

X_2 = *Level 5 Explanatory Variable*

Figure 20 - Regression Equation for Growth Definitions #1 and #2

$$E(y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots + \beta_{55} X_{55}$$

Definition #3

Y = *Level 1 EAC Change*

X_1 = *Level 3 Explanatory Variable*

X_2 = *Level 5 Explanatory Variable*

$$\sum_{n=3}^{55} X_n = Independent\ Variables\ listed\ in\ Appendix\ C$$

Definition #4

Y = *Level 1 LRE Change*

X_1 = *Level 3 Explanatory Variable*

X_2 = *Level 5 Explanatory Variable*

$$\sum_{n=3}^{55} X_n = Independent\ Variables\ listed\ in\ Appendix\ C$$

Figure 21 - Regression Equation for Growth Definitions #3 and #4

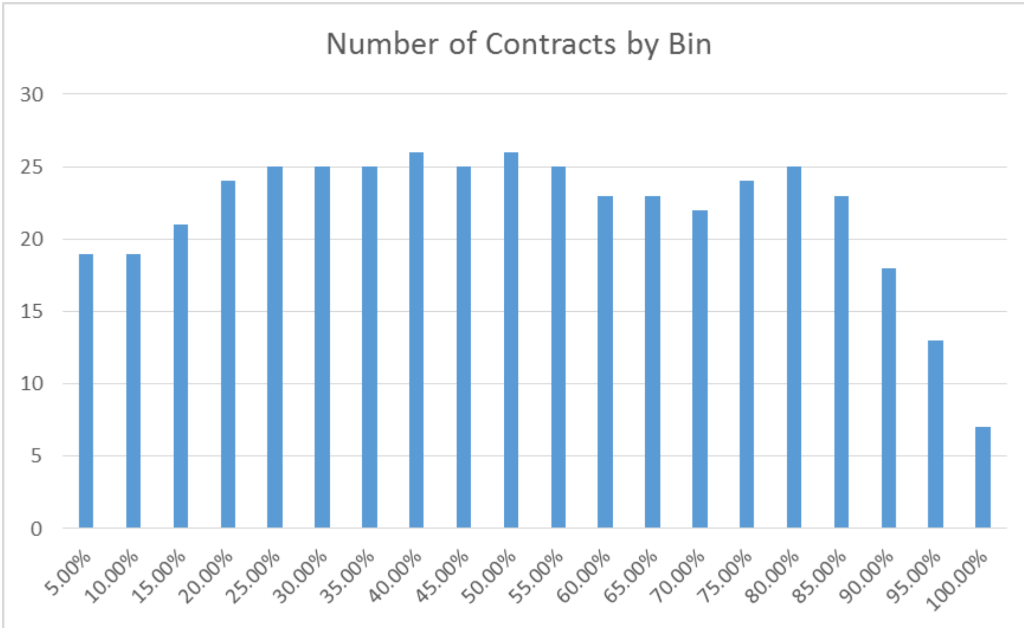


Figure 22 - Number of Contracts by Bin

For each of our explanatory variables, we ran twenty different multiple regression models, one model for each percent complete bin.

Since this is an early attempt into examining EVM data below level three, we were not sure which elements were significant. We used stepwise regression for all of our models in order to determine which independent variables to include. Each model had the potential to include our level three and five variable and fifty additional independent variables. Appendix C contains a list of the additional independent variables. However, upon running stepwise regression for definitions #1 and #2, the stepwise regression did not include our level three and five explanatory variables. After we learned of this, we only included the level three and five explanatory variables for our model using definition #1 and #2. In the following sections, we will reveal the results for each definition of cost growth.

Cost Growth Definition #1 Results

Table 16 details the results of the twenty multiple regression models ran using definition #1. The second column represents the number of iterations conducted for each percent complete. Multiple iterations where run if Cook's D detected at least one contract that was overly influential. An overly influential contract is defined as contract with a Cook's D greater than 0.5. We excluded overly influential contracts and repeated the model. Once complete with the model, any overly influential contracts would then be included for the next percent complete model.

The sixth column represents the number of observations within model. An observation represents one contract. The final column displays the number of independent variables used in the model. For definition #1, this value will not be larger than two because all the models were limited to level three and five explanatory variables. At the 95% percent complete bin, we used only one independent variable because the cumulative change for level three and five had a high level of multicollinearity. Appendix D has the complete JMP® output and Cook's D for each of the models.

Table 16 – Cost Growth Definition #1 JMP® Results

Percent Complete	Number of Interations	R^2	Adjusted R^2	Prob > F	Number of Observations	#IV
5%	1	0.008234	-0.10844	**0.9321**	20	2
10%	2	0.025397	-0.09643	**0.814**	19	2
15%	2	0.031998	-0.07556	**0.7463**	21	2
20%	3	0.094713	-0.00587	**0.4084**	21	2
25%	3	0.018638	-0.0795	**0.8285**	23	2
30%	3	0.032951	-0.05915	**0.7034**	24	2
35%	3	0.058247	-0.03144	**0.5325**	24	2
40%	2	0.159495	0.089453	**0.1243**	27	2
45%	1	0.097554	0.02235	**0.2918**	27	2
50%	4	0.00382	-0.08674	**0.9588**	25	2
55%	1	0.064663	-0.01328	**0.4483**	27	2
60%	2	0.023485	-0.06952	**0.7792**	24	2
65%	1	0.018631	-0.07058	**0.8131**	25	2
70%	2	0.034704	-0.06183	**0.7024**	23	2
75%	2	0.152431	0.07171	**0.1761**	24	2
80%	2	0.33358	-0.0507	**0.6769**	26	2
85%	1	0.179567	0.101431	**0.1252**	24	2
90%	1	0.034002	-0.08675	**0.7582**	19	2
95%	2	0.19763	0.117393	**0.1476**	12	1
100%	4	1	1		3	2

Table 17 lists all the contracts removed while examining definition #1. The fourth column displays the total number of times a contract exclusion occurred and the final column displays the excluded bins for each contract.

Table 17 – Cost Growth Definition #1 Influential Contracts

Service	Program	Contract Number	Total	Excluded Bins			
Navy	AGM-88E AARGM - AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program	N00019-03-C-0353	1	100%			
Navy	CEC – Cooperative Engagement Capability	N00024-05-C-5100	1	100%			
Army	Chem Demil - CMA	DACA87-89-C-0076	1	95%			
Navy	DDG 1000 - ZUMWALT CLASS Destroyer	N00024-05-C-5346	1	75%			
Navy	DDG 51- ARLEIGH BURKE CLASS Guided Missile Destroyer	N00024-02-C-2304	2	70%	75%		
Army	EXCALIBUR - Family of Precision, 155mm Projectiles	DAAE30-98-C-1032	1	20%			
Army	FBCB2 - Force XXI Battle Command Brigade and Below Program	W15P7T-04-D-G205	20	ALL			
Navy	H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter	N00019-06-G-0001	20	ALL			
Navy	LCS - Littoral Combat Ship	N00024-03-C-2310	3	20%	25%	100%	
Navy	LCS - Littoral Combat Ship	N00024-11-C-2301	4	15%	20%	25%	30%
Navy	LPD 17 - SAN ANTONIO CLASS Amphibious Transport Dock Ship	N00024-04-C-2204	1	60%			
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-04-C-0130	2	20%	50%		
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012	2	10%	35%		
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61340-11-C-0004	4	30%	35%	40%	50%
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-00-C-0277	3	80%	95%	100%	
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-12-C-0059	7	10% - 35%	50%		
Air Force	WGS – Wideband Global SATCOM Program	FA8808-06-C-0001	2	100%			

Due to the high p-value for the F test, definition #1 provided no useful models for our research.

Cost Growth Definition #3 Results

Method to Select Independent Variables

For definition #3, we ran a stepwise regression for each model to determine which variables were significant at each percent complete bin. The only exception was at 70% complete. Stepwise regression was not able to create a model at 70%. Therefore, we manually created the model by using our level three explanatory variable and the square of our level three explanatory variable. Figure 23 illustrates the number of variables each model used, as well as the number of variables found significant in each percentage complete bin.

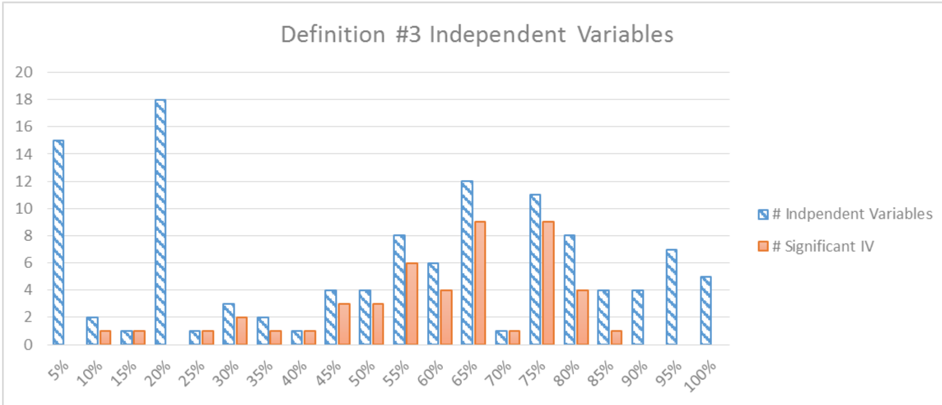


Figure 23 – Cost Growth Definition #3 Independent Variables by Percent Complete

Table 18 displays the results of the twenty multiple regression models ran using definition #3. The first seven columns are structured the same as the first seven columns of Table 16. The three additional columns contain the number of significant variables found in each model and if the model contained either of our level three or level five explanatory variable. Appendix F has the complete JMP® output for each of the models.

Table 18 – Cost Growth Definition #3 JMP® Results

Percent Complete	Number of Interations	R^2	Adjusted R^2	Prob > F	Number of Observations	#IV	# Significant IV	Include Level 3 variable (Y/N)	Include Level 5 variable (Y/N)
5%	4	0.500839	0.084872	0.3498	34	15	0	N	N
10%	3	0.225539	0.178602	0.0147	36	2	1	N	N
15%	3	0.167795	0.144018	0.0118	37	1	1	N	N
20%	6	0.747205	0.397181	0.0841	32	18	0	N	N
25%	3	0.178451	0.15563	0.0082	38	1	1	N	N
30%	7	0.515625	0.463728	0.0001	32	3	2	N	N
35%	3	0.308683	0.248569	0.0143	26	2	1	**Y**	N
40%	3	0.178451	0.15563	0.0082	38	1	1	N	N
45%	9	0.993052	0.988421	0.0001	11	4	3	**Y**	N
50%	10	0.991076	0.982151	0.0002	9	4	3	**Y**	N
55%	7	0.996923	0.993406	0.0001	16	8	6	**Y**	N
60%	6	0.906008	0.843347	0.0004	16	6	4	N	**Y**
65%	2	0.993305	0.984379	0.0001	22	12	9	**Y**	N
70%	**	0.752003	0.725898	0.0001	22	2	1	**Y**	N
75%	3	0.994692	0.988853	0.0001	22	11	9	**Y**	N
80%	3	0.968438	0.950402	0.0001	23	8	4	**Y**	N
85%	2	0.257657	0.147681	0.0802	32	4	1	N	N
90%	2	0.046627	-0.08049	0.8303	35	4	0	N	N
95%	2	0.145953	-0.0602	0.6654	37	7	0	N	N
100%	1	0.034283	-0.11661	0.948	38	5	0	N	N

Table 19 lists all the contracts removed while examining definition #3. The fourth column displays the total number of times a contract exclusion occurred and the final column displays the excluded bins for each contract.

Table 19 – Cost Growth Definition #3 Influential Contracts

Service	Program	Contract Number	Total	Excluded Bins			
Navy	AAG - Advanced Arresting Gear Program	N68335-03-C-0205	4	45%	50%	60%	65%
Navy	AMDR - Air & Missile Defense Radar	N00024-10-C-5359	1	70%			
Air Force	B-2 MOP - Massive Ordnance Penetrator	F33657-99-D-0028	5	45% - 60%	70%		
Army	Chem Demil - CMA	DACA87-89-C-0076	2	50%	70%		
Army	Chem Demil - CMA	DAAA09-97-C-0025	3	55%	70%	85%	
Navy	DDG 1000 - ZUMWALT CLASS Destroyer	N00024-05-C-5346	3	45%	55%	70%	
Navy	DDG 51- ARLEIGH BURKE CLASS Guided Missile Destroyer	N00024-02-C-2304	2	50%	70%		
Navy	EA-18G - Airborne Electronic Attack variant of the F/A-18 aircraft	N00019-04-C-0005	2	45%	70%		
Army	EXCALIBUR - Family of Precision, 155mm Projectiles	DAAE30-98-C-1032	2	50%	55%		
Army	EXCALIBUR - Family of Precision, 155mm Projectiles	W15QKN-08-C-0530	2	45%	70%		
Army	FBCB2 - Force XXI Battle Command Brigade and Below Program	W15P7T-04-D-G205	20	All			
Navy	H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter	N00019-06-G-0001	20	All			
Army	IAMD - Integrated Air & Missile Defense	W31P4Q-08-C-0418	2	50%	70%		
Air Force	ISPAN - Integrated Strategic Planning and Analysis Network - Block 1	FA8722-04-C-0009	3	30%	50%	70%	
Army	JAGM – Joint Air-to-Ground Missile	W31P4Q-08-C-A123	1	70%			
Navy	JPALS - Joint Precision Approach and Landing System	N00019-08-C-0034	1	55%			
Navy	JSOW (BASELINE/UNITARY) - Joint Stand-Off Weapon Baseline Variant and Unitary Warhead Variant	N00019-05-G-0008	2	45%	50%		
Army	JTRS GMR – Joint Tactical Radio System Ground Mobile Radio	DAAB07-02-C-C403	10	5% - 20%	50% - 60%	70%	85% - 90%
Navy	LCS - Littoral Combat Ship	N00024-03-C-2310	12	20%	30%	45% - 60%	70% - 95%
Navy	LPD 17 - SAN ANTONIO CLASS Amphibious Transport Dock Ship	N00024-04-C-2204	3	55%	65%	70%	
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-04-C-0130	3	45%	70%	85%	
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-08-C-0005	5	45% - 50%	70% - 75%	85%	
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-09-C-0059	2	10%	65%		
Navy	MH-60S - Multi-Mission Combat Support Helicopter	N00019-03-G-0003	4	30%	55%	70%	80%
Air Force	MPS – Mission Planning System	FA8720-04-D-0005	2	55%	70%		
Navy	MQ-4C Triton (Formerly BAMS)	N00019-08-C-0023	2	45%	50%		
Navy	P-8A - Poseidon Program	N00019-04-C-3146	1	70%			
Navy	SM-6 – Standard Missile-6	N00024-09-C-5305	2	45%	50%		
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012	9	20%	30%	45% - 60%	70% - 80%
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61340-11-C-0004	7	5%	20%	30%	45% - 60%
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61339-08-D-0004	5	5%	20%	55%	70% 80%
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-00-C-0277	6	45%	50%	60%	70% - 80%
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-12-C-0059	7	5%	20%	30%	45% - 60%
Air Force	WGS – Wideband Global SATCOM Program	FA8808-06-C-0001	5	50%	60% - 70%	90%	

Using definition #3, fourteen of our twenty models had an F-test less than our alpha. In addition, nine of the twenty models contained either our level three or five explanatory variable. Out of the nine models that contained either our level three or five explanatory variable, the level three variable was used in eight different models: 35%, 45%, 50%, 55%, 65%, 70%, 75% and 80%, while our level five explanatory variable was used once at 60%.

Evaluating the LRE

In the following sections, we examine the results using the LRE.

Distribution of Response Variable

While conducting our analysis, we detected two extreme outlier contracts based on level one LRE growth. Contract N00024-09-C-5305 and N00019-06-G-0001 grew 13,374% and 4,346% respectively. Figure 24 displays the distribution of the percent change in level one's LRE.

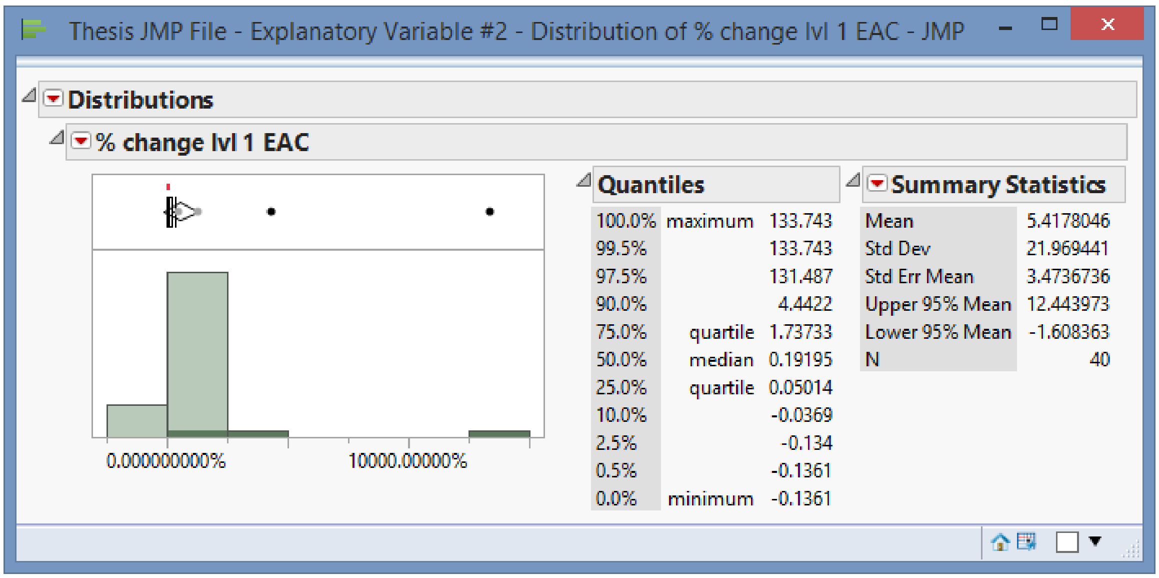


Figure 24 - Distribution of Percent Change of Level 1 LRE

After removing the two extreme outliers, three additional contracts became outliers. Figure 25 displays the distribution after we removed the two extreme outliers. As Figure 25 indicates, there are now three additional outliers.

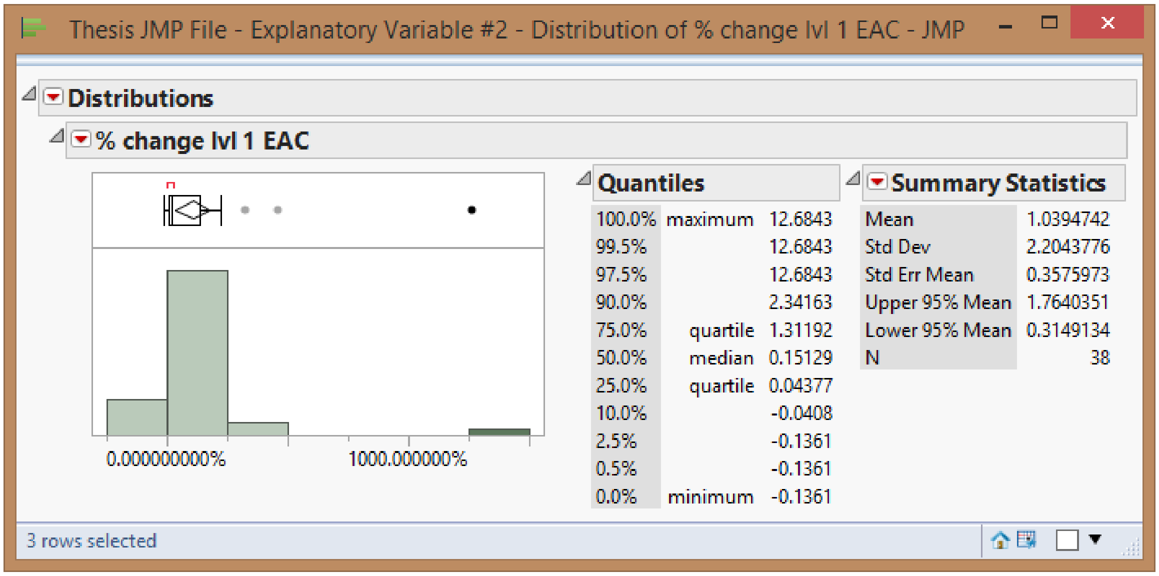


Figure 25 - Distribution of Percent Change of Level 1 LRE (Excluding two extreme outliers)

Figure 26 displays the distribution of the percent change of level one LRE after removing all outliers.

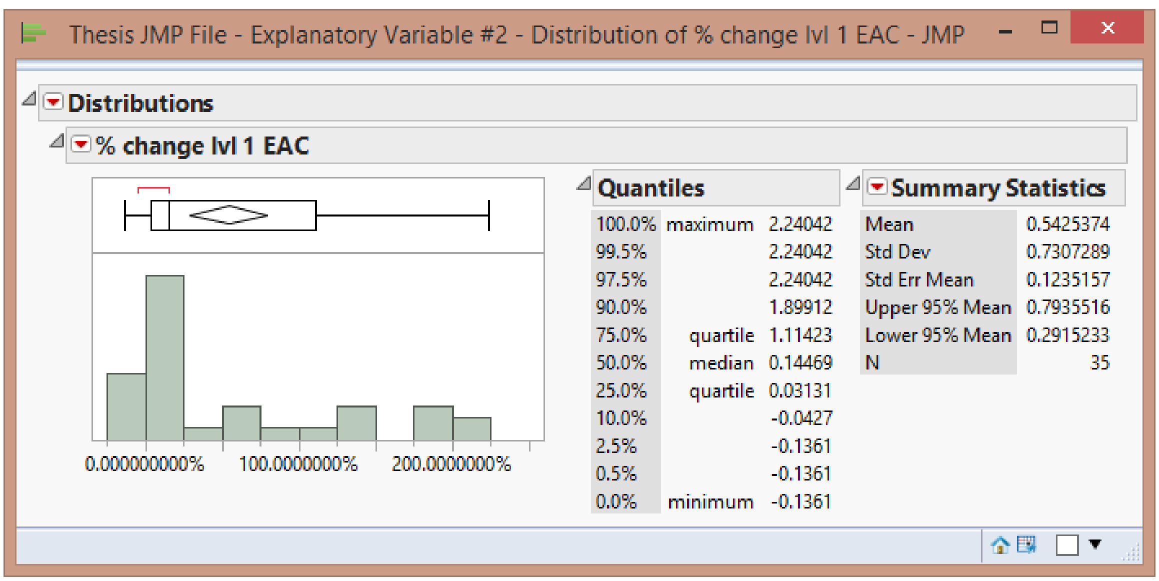


Figure 26 - Distribution of Percent Change of Level 1 LRE (Excluding three additional outliers)

By excluding these five contracts, it lowered our mean LRE growth from 542% to 54% and lowered the standard deviation from 2197% to 73%. We identified five outliers, however, in our models, we initially only excluded the two extreme outliers. Table 20 details the five outlier contracts and the percent change in level one EAC.

Table 20 - LRE Contract Outliers

% change lvl 1 EAC	Service	Project Name	Prime Contract Number
13374.35%	Navy	SM-6 – Standard Missile-6	N00024-09-C-5305
4346.86%	Navy	H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter	N00019-06-G-0001
1268.43%	Army	FBCB2 - Force XXI Battle Command Brigade and Below Program	W15P7T-04-D-G205
457.44%	Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012
325.25%	Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-12-C-0059

The first two contracts in Table 20 are the two extreme outliers, while the next three were the subsequent outliers. Next, we briefly explain and compare each outlier with the outliers using the EAC.

The most extreme outlier using the LRE was the Navy's Standard Missile – 6 (N00024-09-C-5305). This contract did not register as an outlier using the EAC. Its level one EAC percent change was 116.04%. Lack of EVM data is the cause of the discrepancy. The contractor reported an LRE of $2,079,916 in July 2010; however, they did not report any EVM data until September 2010 for $120,489,469. The difference in the beginning value can explain the drastic difference between the percent growth of the LRE and EAC.

The next extreme outlier was the Navy's H-1 Upgrade (N00019-06-G-0001). This contract grew 11,606.53% using the EAC. Figure 27 displays the level one LRE growth compared to the level one BAC growth. The key differences between the LRE and EAC for this contract are the starting and ending value. The beginning EAC and LRE are $702,478 and $1,375,089, respectively. The ending values are $82,235,822 and $61,148,373, respectively. In addition, throughout the contract, the EAC was consistently higher.

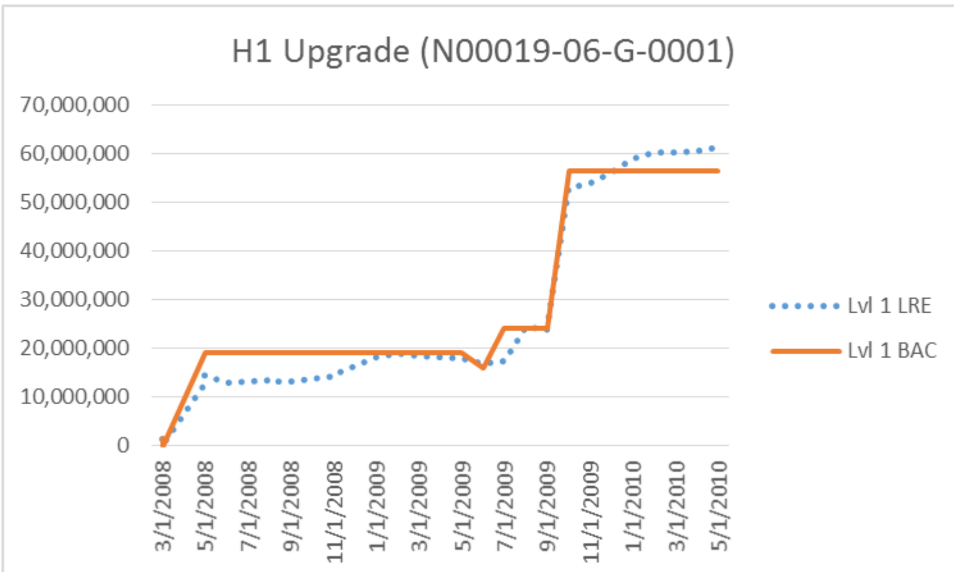


Figure 27 - H1 Upgrade LRE growth

The next outlier contract was the Army's FBCB2 (W15P7T-04-D-G205). The difference in growth between the LRE and EAC is 1405.37% and 1268.43%. Using either the LRE or EAC, the contract had a constant growth since the contract began.

The Navy's V-22 (N00421-10-D-0012) was the next outlier. There was virtually no difference with the percent change of the LRE and the EAC. The EAC grew 451.70% and the LRE grew 457.44%.

The last outlier was the Navy's VTUAV (N00019-12-C-0059). This contract also was an outlier using the percent change in EAC. Its EAC growth was 549.06% compared to 325.25% using the percent change of the LRE. Figure 28 displays the level one LRE and BAC for this contract. As Figure 28 displays, there was a change in scope early within the contract's life.

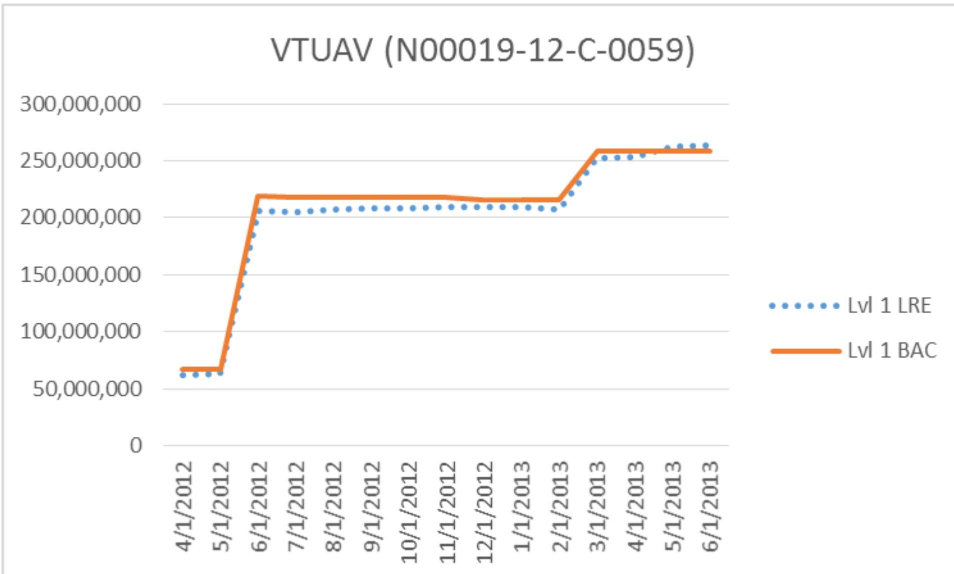


Figure 28 - VTUAV LRE Growth

Multiple Regression Results using LRE

As mentioned earlier in this chapter, we used only the level three and five explanatory variables for definition #2 and we used stepwise regression to determine which variables to add for definition #4.

Cost Growth Definition #2 Results

Table 21 details the results of the twenty multiple regression models ran applying definition #2. Similar to definition #1, we only included the level three and five variables in each model. Appendix E has the complete JMP® output for each of the models.

Table 21 – Cost Growth Definition #2 JMP® Results

Percent Complete	Number of Interations	R^2	Adjusted R^2	Prob > F	Number of Observations	#IV
5%	2	0.016459	-0.10648	0.8757	19	2
10%	7	0.271891	0.211215	0.0558	14	1
15%	4	0.072469	0.01449	0.28	18	1
20%	1	0.030431	-0.05388	0.7009	26	2
25%	1	0.005493	-0.03594	0.719	26	1
30%	7	0.105754	0.053151	0.1743	19	1
35%	4	0.029098	-0.01945	0.4479	22	1
40%	3	0.015432	-0.07407	0.8428	25	2
45%	1	0.014753	-0.02466	0.5462	27	1
50%	2	0.049447	0.008119	0.2854	25	1
55%	1	0.043954	-0.03572	0.5831	27	2
60%	1	0.011253	-0.08291	0.888	24	2
65%	1	0.009038	-0.03405	0.6512	25	1
70%	1	0.003963	-0.0909	0.9592	24	2
75%	1	0.080927	0.040967	0.1681	25	1
80%	4	0.002549	-0.04279	0.8148	24	1
85%	1	0.001908	-0.04149	0.8357	25	1
90%	3	0.256683	0.142327	0.1424	16	2
95%	1	0.001877	-0.0813	0.8831	14	1
100%	5	Excluded all contracts			0	0

Table 22 lists all the contracts removed while examining definition #2. The fourth column displays the total number of times a contract exclusion occurred and the final column displays the excluded bins for each contract. Due to the high p-value for the F test, definition #2 provided no useful models for our research.

Table 22 – Cost Growth Definition #2 Influential Contracts

Service	Program	Contract Number	Total	Excluded Bins			
Navy	AGM-88E AARGM - AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program	N00019-03-C-0353	1	100%			
Navy	AMDR - Air & Missile Defense Radar	N00024-10-C-5359	1	80%			
Navy	CEC – Cooperative Engagement Capability	N00024-05-C-5100	1	100%			
Army	Chem Demil - CMA	DACA87-89-C-0076	1	30%			
Army	EXCALIBUR - Family of Precision, 155mm Projectiles	W15QKN-08-C-0530	1	30%			
Army	FBCB2 - Force XXI Battle Command Brigade and Below Program	W15P7T-04-D-G205	7	10% - 15%	30% - 35%	50%	80% 90%
Navy	H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter	N00019-06-G-0001	20	ALL			
Army	JAGM – Joint Air-to-Ground Missile	W31P4Q-08-C-A123	2	15%	90%		
Navy	JPALS - Joint Precision Approach and Landing System	N00019-08-C-0034	2	10%	30%		
Navy	JSOW (BASELINE/UNITARY) - Joint Stand-Off Weapon Baseline Variant and Unitary Warhead Variant	N00019-05-G-0008	2	30%	35%		
Navy	LCS - Littoral Combat Ship	N00024-03-C-2310	1	100%			
Navy	LCS - Littoral Combat Ship	N00024-11-C-2301	2	15%	40%		
Navy	LPD 17 - SAN ANTONIO CLASS Amphibious Transport Dock Ship	N00024-04-C-2204	20	ALL			
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-04-C-0130	1	50%			
Navy	SM-6 – Standard Missile-6	N00024-09-C-5305	20	ALL			
Navy	SM-6 – Standard Missile-6	N00024-04-C-5344	1	100%			
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012	5	10%	30% - 35%	40%	80%
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61339-08-D-0004	1	100%			
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-00-C-0277	1	100%			
Air Force	WGS – Wideband Global SATCOM Program	FA8808-06-C-0001	1	100%			
Army	WIN-T Inc. 3 - Warfighter Information Network Tactical Increment 3	DAAB07-02-C-F404	1	90%			

Cost Growth Definition #4 Results

Method to Select Independent Variables

For definition #4, we ran a stepwise regression for each model to determine which variables were significant at each percent complete bin. The only exception was at 90% complete. Stepwise regression was not able to create a model at 90%. Therefore, we manually created the model by using our level three explanatory variable and the square of our level three explanatory variable. Table 23 illustrates the results of the twenty multiple regression models ran applying definition #4. Appendix H has the complete JMP® output for each of the models.

Table 23 – Cost Growth Definition #4 JMP® Results

Percent Complete	Number of Interations	R^2	Adjusted R^2	Prob > F	Number of Observations	#IV	# Significant IV	Include Level 3 variable (Y/N)	Include Level 5 variable (Y/N)
5%	1	0.147679	0.096023	0.0716	36	2	0	N	N
10%	1	0.18978	0.165954	0.0079	36	1	1	N	N
15%	1	0.251717	0.206366	0.0084	36	2	1	N	N
20%	5	0.644684	0.348587	0.1014	23	10	0	N	N
25%	3	0.55403	0.451114	0.001	33	6	1	N	N
30%	1	0.071065	0.014766	0.2963	36	2	0	N	N
35%	2	0.949797	0.698785	0.1026	25	20	0	N	N
40%	6	0.991617	0.984166	0.0001	18	8	6	N	**Y**
45%	2	0.60629	0.570499	0.0001	25	2	2	**Y**	N
50%	7	0.955606	0.947535	0.0001	14	2	2	N	**Y**
55%	4	0.999476	0.998951	0.0001	15	7	6	**Y**	N
60%	1	0.992805	0.983211	0.0001	22	12	9	**Y**	N
65%	3	0.880398	0.861998	0.0001	16	2	1	**Y**	N
70%	9	0.038553	-0.03012	0.4661	16	1	0	N	N
75%	2	0.994196	0.987102	0.0001	21	11	7	**Y**	N
80%	1	0.924452	0.893344	0.0001	25	7	4	**Y**	N
85%	4	0.901075	0.89448	0.0001	17	1	1	**Y**	N
90%	**	0.919212	0.907671	0.0001	17	2	1	**Y**	N
95%	2	0.857263	0.643157	0.1002	11	6	0	N	N
100%	2	0.099865	0.006748	0.3761	33	3	0	N	N

Table 24 lists all the contracts removed while examining definition #4. The fourth column displays the total number of times a contract exclusion occurred and the final column displays the excluded bins for each contract.

Table 24 – Cost Growth Definition #4 Influential Contracts

Service	Program	Contract Number	Total	Excluded Bins			
Navy	AAG - Advanced Arresting Gear Program	N68335-03-C-0205	5	50%	65%	70%	85% - 90%
Navy	AGM-88E AARGM - AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program	N00019-03-C-0353	2	85%	100%		
Navy	AMDR - Air & Missile Defense Radar	N00024-10-C-5359	1	90%			
Air Force	B-2 MOP - Massive Ordnance Penetrator	F33657-99-D-0028	3	50%	65%	85%	
Navy	CEC – Cooperative Engagement Capability	N00024-05-C-5100	2	90%	95%		
Army	Chem Demil - CMA	DACA87-89-C-0076	5	20%	40%	65% - 70%	90%
Army	Chem Demil - CMA	DAAA09-97-C-0025	4	50%	55%	70%	90%
Navy	DDG 1000 - ZUMWALT CLASS Destroyer	N00024-05-C-5346	4	40%	70%	75%	90%
Navy	DDG 51- ARLEIGH BURKE CLASS Guided Missile Destroyer	N00024-02-C-2304	1	70%			
Navy	EA-18G - Airborne Electronic Attack variant of the F/A-18 aircraft	N00019-04-C-0005	4	20%	50%	55%	90%
Army	EXCALIBUR - Family of Precision, 155mm Projectiles	DAAE30-98-C-1032	2	70%	90%		
Army	EXCALIBUR - Family of Precision, 155mm Projectiles	W15QKN-08-C-0530	1	70%			
Army	FBCB2 - Force XXI Battle Command Brigade and Below Program	W15P7T-04-D-G205	20	ALL			
Navy	H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter	N00019-06-G-0001	20	ALL			
Army	IAMD - Integrated Air & Missile Defense	W31P4Q-08-C-0418	2	20%	70%		
Air Force	ISPAN - Integrated Strategic Planning and Analysis Network - Block 1	FA8722-04-C-0009	6	20%	50% - 70%	85%	
Army	JAGM – Joint Air-to-Ground Missile	W31P4Q-08-C-A123	2	65%	90%		
Navy	JPALS - Joint Precision Approach and Landing System	N00019-08-C-0034	1	40%			
Navy	JPALS - Joint Precision Approach and Landing System	N00019-08-C-0034	2	20%	25%		
Navy	JSOW (BASELINE/UNITARY) - Joint Stand-Off Weapon Baseline Variant and Unitary Warhead Variant	N00019-05-G-0008	4	20%	55%	70%	90%
Army	JTRS GMR – Joint Tactical Radio System Ground Mobile Radio	DAAB07-02-C-C403	4	50%	55%	70%	90%
Navy	LCS - Littoral Combat Ship	N00024-03-C-2310	8	20% 40%	50% - 55%	70%	85% - 95%
Navy	LCS - Littoral Combat Ship	N00024-11-C-2301	2	40%	70%		
Navy	LPD 17 - SAN ANTONIO CLASS Amphibious Transport Dock Ship	N00024-04-C-2204	20	ALL			
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-04-C-0130	3	40%	50%	70%	
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-08-C-0005	4	20%	40%	50%	70%
Navy	MH-60R - Multi-Mission Helicopter Upgrade	N00019-09-C-0059	2	20%	55%		
Navy	MH-60S - Multi-Mission Combat Support Helicopter	N00019-03-G-0003	1	50%			
Navy	MQ-4C Triton (Formerly BAMS)	N00019-08-C-0023	1	70%			
Navy	SM-6 – Standard Missile-6	N00024-09-C-5305	20	ALL			
Navy	SM-6 – Standard Missile-6	N00024-04-C-5344	1	90%			
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N00421-10-D-0012	16	20%	25%	85% - 100%	
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61340-11-C-0004	2	20%	55%		
Navy	V-22 - OSPREY Joint Advanced Vertical Lift Aircraft	N61339-08-D-0004	2	65%	75%		
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-00-C-0277	2	70%	90%		
Navy	VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout)	N00019-12-C-0059	5	20%	25%	50% - 55%	70%
Air Force	WGS – Wideband Global SATCOM Program	FA8808-06-C-0001	8	20%	50% - 70%	85% - 90%	100%
Army	WIN-T Inc. 3 - Warfighter Information Network Tactical Increment 3	DAAB07-02-C-F404	1	90%			

Using definition #4, thirteen of our twenty models had an F-test less than our alpha. In addition, ten of the twenty models contained either our level three or level five explanatory variable. Out of the ten models that contained either our level three or level five explanatory variable, the level three variable was used in eight different models: 45%, 55%, 60%, 65%, 75%, 80%, 85% and 90%, while our level five explanatory variable was used twice at 40% and 50%.

Comparing Level Three EVM Data with Level Five EVM Data

While conducting our analysis of lower level EVM data, we noticed a high correlation between the contractor's level three and five data. In order to verify this, we conducted a Fit Y by X comparing the level three variable to the level five variable. We conducted this test using both the contractor's EAC and the recalculated EAC. Figure 29 displays the results comparing the levels three and five using the LRE. The slope of the fit line for this bin was .9983099, indicating almost perfect correlation between the level three and level five variables.

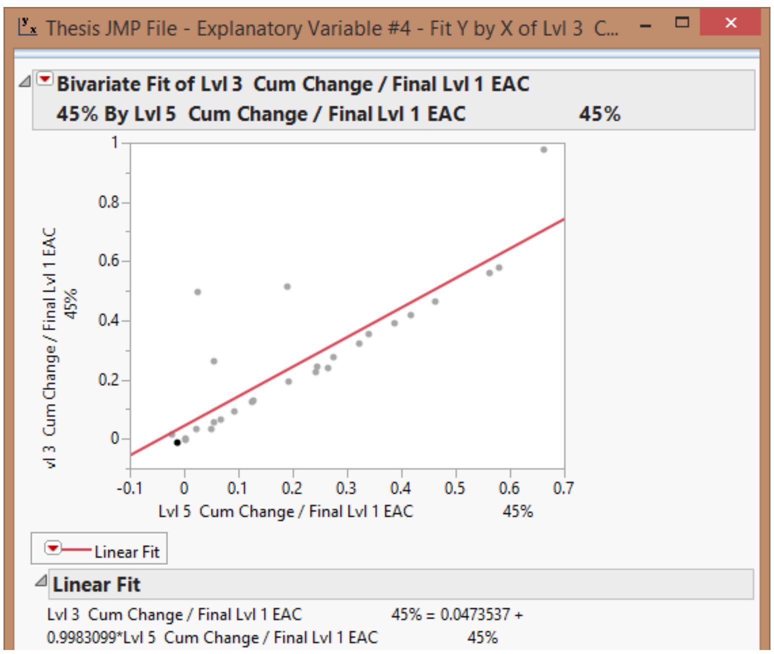


Figure 29 - Comparing Level three and Level five LRE at 45% complete

Figure 30 displays the results comparing the levels three and five using the EAC. The slope of the fit line for this bin was .6470539. In contrast to the LRE's slope at 45%, very little correlation is apparent between the level three and level five variable.

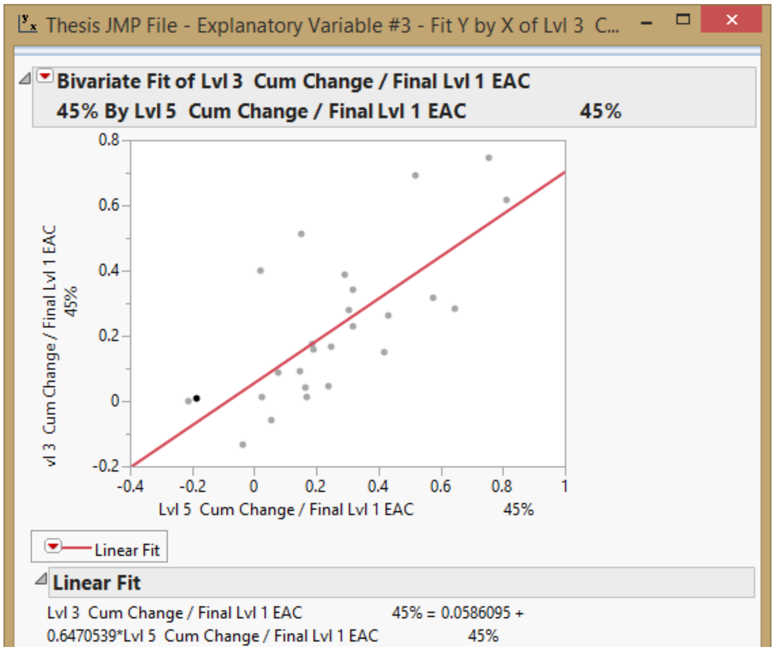


Figure 30 - Comparing Level three and Level five EAC at 45% complete

Appendix I contains the complete results using the contractor's EAC and Appendix J contains the results using the recalculated EAC.

We looked at the slope of the fit line to evaluate the relationship between level three and five. Level three and five variables were identical the closer the slope of the line was to one. Table 25 compares the slope by percent complete for the contractor's EAC and the recalculated EAC. Figure 31 and Figure 32 visually display the slopes. As either the table or figures indicate, the contractor's level three and five variables were almost identical. In addition, Figure 32, illustrates a large increase of the slope in the

100% complete bin. Contract FA8808-06-C-0001 caused this sudden increase at 100%.

If this contract is excluded the slope would decrease to 0.3033184.

Table 25 - Comparing Slopes between Level Three and Five with Respects to the response of EAC and LRE

	LRE	EAC
5%	1.028042	0.020022
10%	0.971286	0.365103
15%	1.111285	0.662947
20%	1.113232	0.085429
25%	1.088484	0.555081
30%	1.071052	0.482034
35%	1.126062	1.052112
40%	1.117613	0.651423
45%	0.99831	0.647054
50%	0.976149	0.610131
55%	0.901014	0.565287
60%	0.886609	0.57314
65%	0.922645	0.561618
70%	0.937097	0.567915
75%	0.969642	0.622586
80%	0.960558	0.528834
85%	0.931023	0.577463
90%	0.933059	0.501941
95%	0.891078	0.554161
100%	1.205188	1.549535
Mean	1.006971	0.586691
Std Dev	0.093836	0.308297

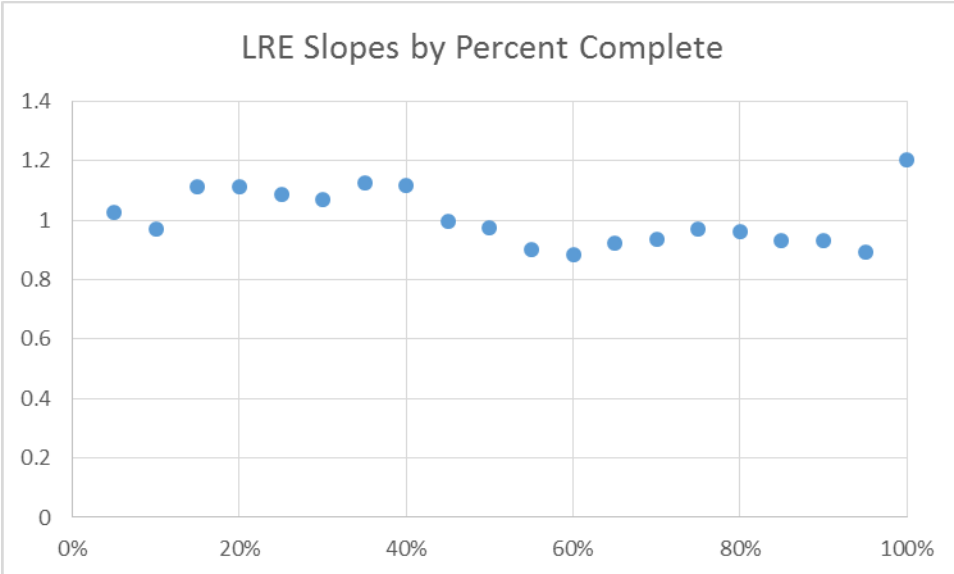


Figure 31 - LRE Slope by Percent Complete

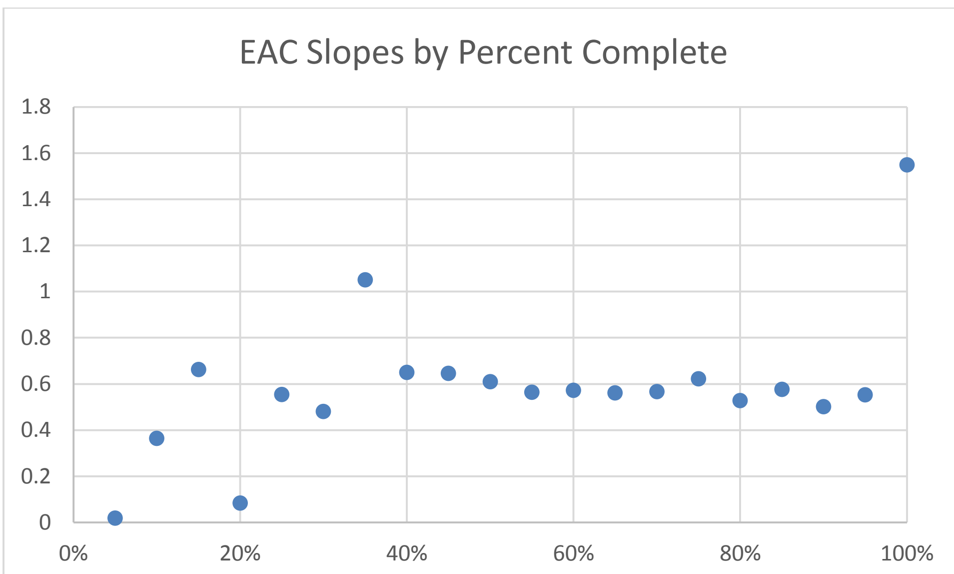


Figure 32 - EAC Slopes by Percent Complete

Summary of Findings

After reviewing the results, we observed definitions #1 and #2 did not provide any useful models. These results indicate that definitions #1 and #2 are not significant to predict overall contract growth. This also indicates the method used to calculate cost growth by definitions #1 and #2 is not effective to predict overall cost growth.

Definitions #3 and #4 had much better results. Definition #3 had fourteen significant models. In addition, it revealed that level three EVM data was predictive of cost growth beginning at 35% with an adjusted R^2 of .248569 and at 45%, the R^2 increased to .988421. Furthermore, none of the models contained both level three and five variables. This may indicate a high level of multicollinearity between the two variables. Stepwise regression selected the level five variable once.

Definition #4 also had promising results. Twelve of the thirteen models were significant and nine of them contained either our level three or level five variable. This model revealed that level five EVM data became predictive of overall cost growth at 40% complete with an adjusted R^2 of .984166. Similar to definition #3 models, none of the models contained both level three and level five variables.

In conclusion, we demonstrated two different techniques to calculate cost growth at lower WBS elements. The first technique, used in definitions #1 and #2, involved only the change in individual lower level elements. This technique proved ineffective to predict overall cost growth and did not provide any significant results. The second technique, used in definitions #3 and #4, evaluated the cumulative change of lower level cost data. This technique did provide significant results as indicated earlier.

Our results also reveal level three and level five EVM data becomes predictive at the 40% complete point of a contract. The results indicate that both the recalculated EAC and the LRE provided by the contractor are predictive at approximately the same point. However, the contractor's level three and level five LRE's were almost identical. Table 25 and Figure 31 identify this correlation.

Our results also indicate level three EVM data is a better predictor of contract cost growth than level five EVM data. As indicated previously, stepwise regression chose level three sixteen times and level five only three times in the forty models between definitions #3 and #4.

Chapter 5: Conclusions

Introduction

In this chapter, we review the purpose of our research and determine if our analysis was able to answer our research questions. We also discuss some limitations and assumptions we had throughout our research. We also briefly review our results and findings from Chapter Four and discuss possible implications on the acquisition community. We conclude this chapter suggesting possible follow-on research ideas.

Review Purpose of research

The purpose of our research was to determine if it would be beneficial for the DoD to require contractors to provide level five EVM data instead of just level three. In this section, we evaluate how our research was able to answer our research purpose. We also look at our research and investigation questions to determine if our research was able to answer them

Our first research question was if level five data is more predictive than level three data. To answer this, we decided to calculate the EAC for each level three and five element. We anticipated from previous research that the EAC would be the best indicator for contract cost growth. We also determined, though limited, sufficient contracts on the DCARC website contained level five EVM data. We were also able to construct a statistical model using stepwise and multiple regression to establish a relationship between WBS level three and five EVM data and cost growth of the overall contract. The answer to our first research question is WBS level five EVM data is not more predictive than level three.

Our second research question became irrelevant due the finding of our first research question. Our second question examined the benefits of level five EVM data compared to the cost to obtain the information. However, we failed to discover what the additional cost would be to obtain this data because we discovered level five EVM data was less predictive.

Limitations in our Research

Our research was limited in two key ways. The first limitation dealt with accessibility to EVM data. Due to the requirements of our research, we were restricted to the EVM-CR database. The main reason for this limitation is the EVM-CR is the most current database of EVM data and the database also contained contracts with lower level EVM data.

Even though there are more than 400 contracts in the EVM-CR, most of them did not meet our requirements. Our screening criteria included, level five EVM data or lower, contract length greater than twelve months and complete EVM cost data. The database contained 98 different contracts with at least level five EVM data. However, many of those contracts were either missing complete EVM data or were not greater than twelve months in length. Our screening criteria limited us to only forty contracts.

Assumptions in our Research

We also made two key assumptions in our research. The first was that the level five EVM data was not biased. This is a concern because the current DoD regulations require contractors to provide level three EVM data unless a contract is determined high

risk or high cost. We assumed these forty contracts represented a random sample of the overall contract population, not just high risk or high cost contracts.

The second assumption necessitated the WBS structures contained in the contracts were CWBS, not PWBS. We made this assumption because WBS level three of a PWBS is equivalent to WBS level one of the CWBS. We assumed that each contract contained the CWBS in order to ensure we were comparing the same level of work across each of the contracts.

There needs to be better clarification of WBS. For example, MIL STD 881C, states a contractor has to report down to WBS level three. Does that mean a contract has to report down to level three for each contract (CWBS) or just that the contractor is required to report down to level three of the project (PWBS). The difference is two additional levels of data. Level three of the CWBS is equivalent to level five of the PWBS.

<u>Briefly Review Results</u>

We were able to establish a relationship between lower level WBS EVM data with the overall contract cost growth. However, our research did not prove WBS level five EVM elements are more predictive than WBS level three EVM elements. Our research proved level three EVM data is a better predictor for overall contract growth than level five EVM data. Based on the data that was available to us, it would not be beneficial for the DoD to require contractors to provide EVM data down to WBS level five.

Follow-on Research

Based on our research, level five is not a better indicator for cost growth than level three. This finding contradicts conventional logic. We created our methodology and statistical models without any bias on the outcome. However, conducting further research using a larger sample size to either confirm or disprove our findings is required.

Our research posed another question referencing the best measurement of an EAC. Should a contractor provide an EAC using EVM data? Two of our statistical models used the contractors EAC and two contained our recalculated EAC. Both the contractor's EAC and the recalculated EAC proved predictive at approximately the same percent complete.

However, when we compared the level three EAC value with the level five EAC values, the contractor's EAC showed very little difference. In contrast, the recalculated EAC for level three and five were completely different. A follow-on research question entails examining the requirements of a contractor to provide the composite EAC.

Appendix A - Acronyms

ACWP (Actual Cost of Work Performed) or **ACTUAL COST -** Cost actually incurred in accomplishing work performed

BAC (Budget At Completion) - Total budget for total contract thru any given level

BCWP (Budgeted Cost for Work Performed) or **EARNED VALUE -** Value of completed work in terms of the work's assigned budget

BCWS (Budgeted Cost for Work Scheduled) or **PLANNED VALUE -** Time-phased Budget Plan for work currently scheduled

CA (Control Account) - Lowest CWBS element assigned to a single focal point to plan & control

EAC (Estimate At Completion) - Estimate of total **Cost** for total contract thru any given level generated

LRE (Latest Revised Estimate) - Contractor's EAC

MR (Management Reserve) - Budget withheld by Contractor PM for unknowns / risk management

PMB (Performance Measurement Baseline) - Contract time-phased budget plan

TAB (Total Allocated Budget) - Sum of all budgets for work on contract = NCC, CBB, or OTB

Appendix B: Contracts Used in Analysis

AAG - Advanced Arresting Gear Program (N68335-03-C-0205)
Contractor: General Atomics Corporation **Contract Type:** CPFF
WBS Type: Electronic / Automated Software
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 6/27/2008 - 5/27/2011

AGM-88E AARGM - AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program (N00019-03-C-0353)
Contractor: Alliant Techsystems, Inc. (ATK) **Contract Type:** CPIF
WBS Type: Missile
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 3/31/2007 - 2/22/2009

AMDR - Air & Missile Defense Radar (N00024-10-C-5359)
Contractor: Northrop Grumman Corporation **Contract Type:** FPIF
WBS Type: Electronic / Automated Software
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 11/5/2010 - 9/29/2012

B-2 MOP - Massive Ordnance Penetrator (F33657-99-D-0028)
Contractor: Northrop Grumman Corporation **Contract Type:** CPFF
WBS Type: Aircraft
Service: Air Force **Phase:** RDT&E
Beginning and Ending Contract Dates: 9/25/2009 - 11/5/2010

CEC – Cooperative Engagement Capability (N00024-05-C-5100)
Contractor: General Dynamics Corporation **Contract Type:** CPAF
WBS Type: Electronic / Automated Software
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 3/30/2009 - 7/29/2011

Chem Demil - CMA (DACA87-89-C-0076)
Contractor: EG&G **Contract Type:** CPAF
WBS Type: Other
Service: Army **Phase:** PROD
Beginning and Ending Contract Dates: 1/31/2000 - 5/26/2013

Chem Demil - CMA (DAAA09-97-C-0025)
Contractor: Washington Demil Company **Contract Type:** FFP
WBS Type: Other
Service: Army **Phase:** PROD
Beginning and Ending Contract Dates: 10/1/2004 - 5/24/2013

DDG 1000 - ZUMWALT CLASS Destroyer (N00024-05-C-5346)
Contractor: Raytheon Company **Contract Type:** CPAF
WBS Type: Ship
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 11/20/2005 - 3/31/2013

DDG 51- ARLEIGH BURKE CLASS Guided Missile Destroyer (N00024-02-C-2304)
Contractor: Northrop Grumman Corporation **Contract Type:** FPIF
WBS Type: Ship
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 6/26/2005 - 5/30/2010

EA-18G - Airborne Electronic Attack variant of the F/A-18 aircraft (N00019-04-C-0005)
Contractor: The Boeing Company **Contract Type:** CPAF
WBS Type: Aircraft
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 2/26/2004 - 2/26/2009

EXCALIBUR - Family of Precision, 155mm Projectiles (DAAE30-98-C-1032)
Contractor: Raytheon Company **Contract Type:** CPIF
WBS Type: Ordance
Service: Army **Phase:** PROD
Beginning and Ending Contract Dates: 10/22/2006 - 2/24/2008

EXCALIBUR - Family of Precision, 155mm Projectiles (W15QKN-08-C-0530)
Contractor: Raytheon Company **Contract Type:** CPIF
WBS Type: Ordance
Service: Army **Phase:** RDT&E
Beginning and Ending Contract Dates: 10/2/2011 - 8/26/2012

FBCB2 - Force XXI Battle Command Brigade and Below Program (W15P7T-04-D-G205)
Contractor: Northrop Grumman Corporation **Contract Type:** CPAF
WBS Type: Electronic / Automated Software
Service: Army **Phase:** RDT&E
Beginning and Ending Contract Dates: 12/31/2004 - 12/31/2009

H-1 UPGRADES (4BW/4BN) - United States Marine Corps Mid-life Upgrade to AH-1W Attack Helicopter and UH-1N Utility Helicopter (N00019-06-G-0001)
Contractor: Bell Helicopter Textron, Inc. **Contract Type:** CPFF
WBS Type: Aircraft
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 3/1/2008 - 5/8/2010

IAMD - Integrated Air & Missile Defense (W31P4Q-08-C-0418)
Contractor: Northrop Grumman Corporation   **Contract Type:** CPIF
WBS Type: Electronic / Automated Software
Service: Army   **Phase:** RDT&E
Beginning and Ending Contract Dates: 9/3/2010 - 7/26/2013

ISPAN - Integrated Strategic Planning and Analysis Network - Block 1 (FA8722-04-C-0009)
Contractor: Lockheed Martin Corporation   **Contract Type:** CPAF
WBS Type: Electronic / Automated Software
Service: Air Force   **Phase:** RDT&E
Beginning and Ending Contract Dates: 10/30/2005 - 3/25/2011

JAGM – Joint Air-to-Ground Missile (W31P4Q-08-C-A123)
Contractor: Lockheed Martin Corporation   **Contract Type:** FPIF
WBS Type: Missile
Service: Army   **Phase:** RDT&E
Beginning and Ending Contract Dates: 11/30/2008 - 5/30/2010

JPALS - Joint Precision Approach and Landing System (N00019-08-C-0034)
Contractor: Rockwell Collins, Inc.   **Contract Type:** Other
WBS Type: Electronic / Automated Software
Service: Navy   **Phase:** Other
Beginning and Ending Contract Dates: 12/5/2008 - 7/2/2010

JPALS - Joint Precision Approach and Landing System (N00019-08-C-0034)
Contractor: Raytheon Company   **Contract Type:** CPIF
WBS Type: Electronic / Automated Software
Service: Navy   **Phase:** RDT&E
Beginning and Ending Contract Dates: 11/21/2008 - 12/31/2009

JSOW (BASELINE/UNITARY) - Joint Stand-Off Weapon Baseline Variant and Unitary Warhead Variant (N00019-05-G-0008)
Contractor: Raytheon Company   **Contract Type:** CPFF
WBS Type: Missile
Service: Navy   **Phase:** RDT&E
Beginning and Ending Contract Dates: 3/25/2007 - 4/1/2012

JTRS GMR – Joint Tactical Radio System Ground Mobile Radio (DAAB07-02-C-C403)
Contractor: The Boeing Company   **Contract Type:** Other
WBS Type: Electronic / Automated Software
Service: Army   **Phase:** Other
Beginning and Ending Contract Dates: 9/29/2005 - 9/30/2010

LCS - Littoral Combat Ship (N00024-03-C-2310)
Contractor: General Dynamics Corporation **Contract Type:** CPIF
WBS Type: Ship
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 11/27/2005 - 4/4/2010

LCS - Littoral Combat Ship (N00024-11-C-2301)
Contractor: Austal **Contract Type:** FPIF
WBS Type: Ship
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 7/27/2012 - 9/27/2013

LPD 17 - SAN ANTONIO CLASS Amphibious Transport Dock Ship (N00024-04-C-2204)
Contractor: Northrop Grumman Corporation **Contract Type:** CPIF
WBS Type: Ship
Service: Navy **Phase:** PROD
Beginning and Ending Contract Dates: 6/24/2007 - 12/20/2009

MH-60R - Multi-Mission Helicopter Upgrade (N00019-04-C-0130)
Contractor: Harris Corporation **Contract Type:** CPAF
WBS Type: Aircraft
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 1/26/2007 - 4/30/2010

MH-60R - Multi-Mission Helicopter Upgrade (N00019-08-C-0005)
Contractor: Telephonics Corporation **Contract Type:** CPIF
WBS Type: Aircraft
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 9/30/2008 - 4/30/2010

MH-60R - Multi-Mission Helicopter Upgrade (N00019-09-C-0059)
Contractor: L-3 Communications **Contract Type:** FPIF
WBS Type: Aircraft
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 8/21/2009 - 11/26/2010

MH-60S - Multi-Mission Combat Support Helicopter (N00019-03-G-0003)
Contractor: Sikorsky Aircraft Corporation **Contract Type:** CPIF
WBS Type: Aircraft
Service: Navy **Phase:** Unknown
Beginning and Ending Contract Dates: 1/31/2006 - 3/31/2009

MPS – Mission Planning System (FA8720-04-D-0005)
Contractor: The Boeing Company **Contract Type:** CPAF
WBS Type: Electronic / Automated Software
Service: Air Force **Phase:** RDT&E
Beginning and Ending Contract Dates: 3/18/2011 - 10/5/2012

MQ-4C Triton (Formerly BAMS) (N00019-08-C-0023)
Contractor: Northrop Grumman Corporation **Contract Type:** CPAF
WBS Type: UAV
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 10/31/2008 - 5/27/2011

P-8A - Poseidon Program (N00019-04-C-3146)
Contractor: Northrop Grumman Corporation **Contract Type:** CPIF
WBS Type: Aircraft
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 6/26/2009 - 1/28/2011

SM-6 – Standard Missile-6 (N00024-09-C-5305)
Contractor: Raytheon Company **Contract Type:** FPIF
WBS Type: Missile
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 7/25/2010 - 2/24/2013

SM-6 – Standard Missile-6 (N00024-04-C-5344)
Contractor: Raytheon Company **Contract Type:** CPAF
WBS Type: Missile
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 12/31/2008 - 8/28/2011

V-22 - OSPREY Joint Advanced Vertical Lift Aircraft (N00421-10-D-0012)
Contractor: Raytheon Company **Contract Type:** CPAF
WBS Type: Aircraft
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 11/19/2010 - 4/26/2013

V-22 - OSPREY Joint Advanced Vertical Lift Aircraft (N61340-11-C-0004)
Contractor: Bell-Boeing V-22 Program Office **Contract Type:** CPIF
WBS Type: Aircraft
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 5/31/2011 - 10/31/2012

V-22 - OSPREY Joint Advanced Vertical Lift Aircraft (N61339-08-D-0004)
Contractor: Bell-Boeing V-22 Program Office **Contract Type:** CPFF
WBS Type: Aircraft
Service: Navy **Phase:** Prod
Beginning and Ending Contract Dates: 11/30/2009 - 10/31/2010

VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout) (N00019-00-C-0277)
Contractor: Northrop Grumman Corporation **Contract Type:** CPIF
WBS Type: UAV
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 9/1/2006 - 12/31/2010

VTUAV - Vertical Takeoff and Land Tactical Unmanned Air Vehicle (Fire Scout) (N00019-12-C-0059)
Contractor: Northrop Grumman Corporation **Contract Type:** CPIF
WBS Type: UAV
Service: Navy **Phase:** RDT&E
Beginning and Ending Contract Dates: 4/27/2012 - 6/28/2013

WGS – Wideband Global SATCOM Program (FA8808-06-C-0001)
Contractor: The Boeing Company **Contract Type:** FFP
WBS Type: Space
Service: Air Force **Phase:** PROD
Beginning and Ending Contract Dates: 11/30/2006 - 12/20/2012

WIN-T Inc. 3 - Warfighter Information Network Tactical Increment 3 (DAAB07-02-C-F404)
Contractor: General Dynamics Corporation **Contract Type:** CPAF
WBS Type: Electronic / Automated Software
Service: Army **Phase:** RDT&E
Beginning and Ending Contract Dates: 1/27/2012 - 12/28/2012

Appendix C: List of Independent Variables used in Model

List of Variables used in Statistical Models

1. Total Number of level three elements in contract
2. Total Number of level three elements with EAC data in contract
3. Total Number of level five elements in contract
4. Total Number of level five elements with EAC data in contract

Dummy Variables used in Statistical Models

1. # Lvl 5 elements with EAC data < = 30
2. # Lvl 5 elements with EAC data > 30 and < 150
3. # Lvl 5 elements with EAC data > = 150
4. RDT&E
5. Production
6. Other Phase
7. Unknown Phase
8. Army
9. Air Force
10. Navy
11. Aircraft
12. Electronic/automated software
13. Missile
14. Ordance
15. Ship
16. Space
17. UAV
18. Other Handbook
19. CPAF
20. CPFF
21. CPIF
22. FFIP
23. Alliant Techsystems, Inc. (ATK)
24. Austal
25. Bell-Boeing V-22 Program Office
26. Bell Helicopter Textron, Inc.
27. EG&G
28. General Atomics Corporation
29. General Dynamics Corporation
30. Harris Corporation

31. L-3 Communications
32. Lockheed Martin Corporation
33. Northrop Grumman Corporation
34. Raytheon Company
35. Rockwell Collins, Inc.
36. Sikorsky Aircraft Corporation
37. Telephonics Corporation
38. The Boeing Company
39. Washington Demil Company
40. Top 3 DoD Contractor
41. Top 5 DoD Contractor
42. Contract length 12-24 Months
43. Contract length 24-36 Months
44. Contract length more than 36 months
45. Percent of program contract covered < 25%
46. Percent of program contract covered 25% - 50%
47. Percent of program contract covered 50% - 75%
48. Percent of program contract covered more than 75%

<u>Appendix D - JMP® Output Screens for Growth Definition #1</u>

Growth Definition #1 Bin - 5%

Thesis JMP File - Response Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

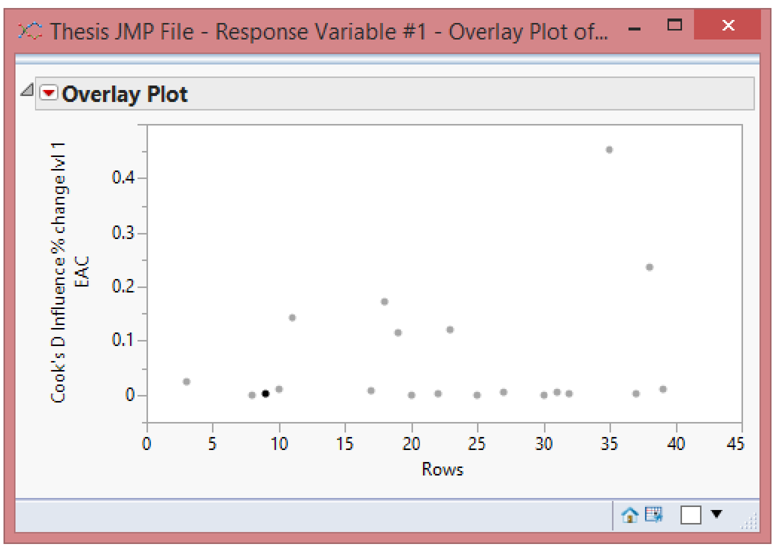
RSquare	0.008234
RSquare Adj	-0.10844
Root Mean Square Error	1.467724
Mean of Response	0.956537
Observations (or Sum Wgts)	20

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.304040	0.15202	0.0706
Error	17	36.621631	2.15421	Prob > F
C. Total	19	36.925671		0.9321

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.9151765	0.382116	2.40	0.0284*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	5%	-0.661564	3.400086	-0.19	0.8480	-0.05697	1.4695134
Lvl 5 Cum Change / Final Lvl 1 EAC	5%	-0.466385	3.006535	-0.16	0.8786	-0.04542	1.4695134



Growth Definition #1 Bin - 10%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

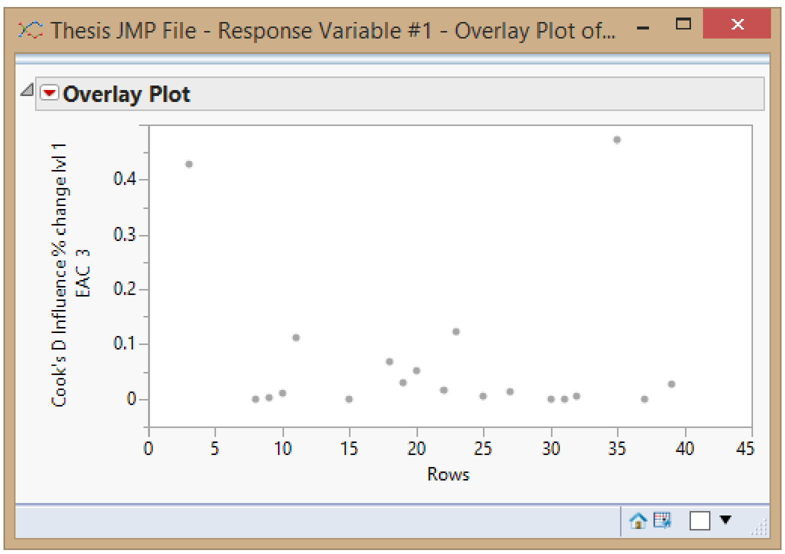
RSquare	0.025397
RSquare Adj	-0.09643
Root Mean Square Error	0.95095
Mean of Response	0.755152
Observations (or Sum Wgts)	19

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.377043	0.188522	0.2085
Error	16	14.468884	0.904305	Prob > F
C. Total	18	14.845927		0.8140

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7518629	0.220374	3.41	0.0036*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	10%	-1.027129	4.34638	-0.24	0.8162	-0.0949	2.6472756
Lvl 5 Cum Change / Final Lvl 1 EAC	10%	2.2864879	4.114293	0.56	0.5861	0.223166	2.6472756



Growth Definition #1 Bin - 15%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

RSquare	0.031998
RSquare Adj	-0.07556
Root Mean Square Error	1.267937
Mean of Response	1.006342
Observations (or Sum Wgts)	21

Analysis of Variance

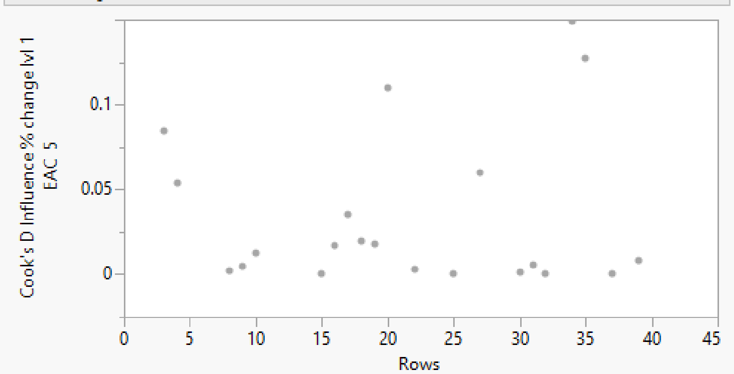
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.956563	0.47828	0.2975
Error	18	28.937945	1.60766	Prob > F
C. Total	20	29.894508		0.7463

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.0379022	0.292935	3.54	0.0023*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	15%	3.3240025	9.691745	0.34	0.7356	0.085751	1.1624016
Lvl 5 Cum Change / Final Lvl 1 EAC	15%	2.9149857	5.686174	0.51	0.6144	0.128173	1.1624016

Thesis JMP File - Explanatory Variable #1 - Overlay Plot ...

Overlay Plot



Growth Definition #1 Bin - 20%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

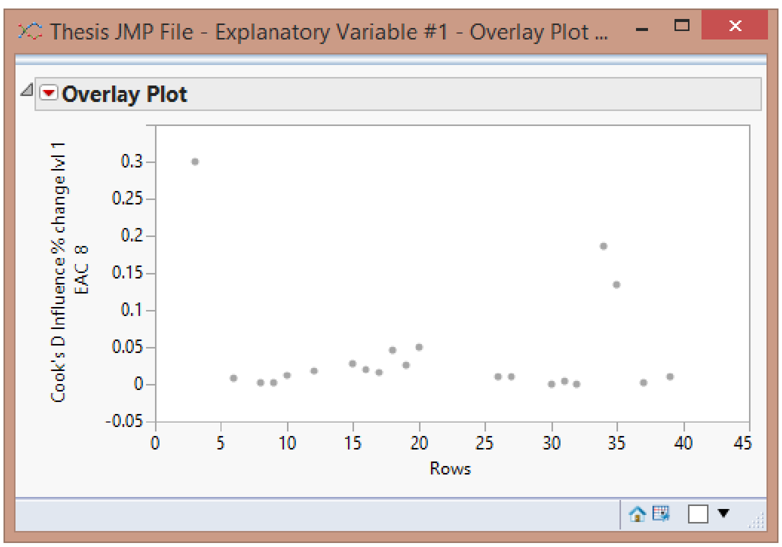
RSquare	0.094713
RSquare Adj	-0.00587
Root Mean Square Error	1.24583
Mean of Response	0.994568
Observations (or Sum Wgts)	21

Analysis of Variance

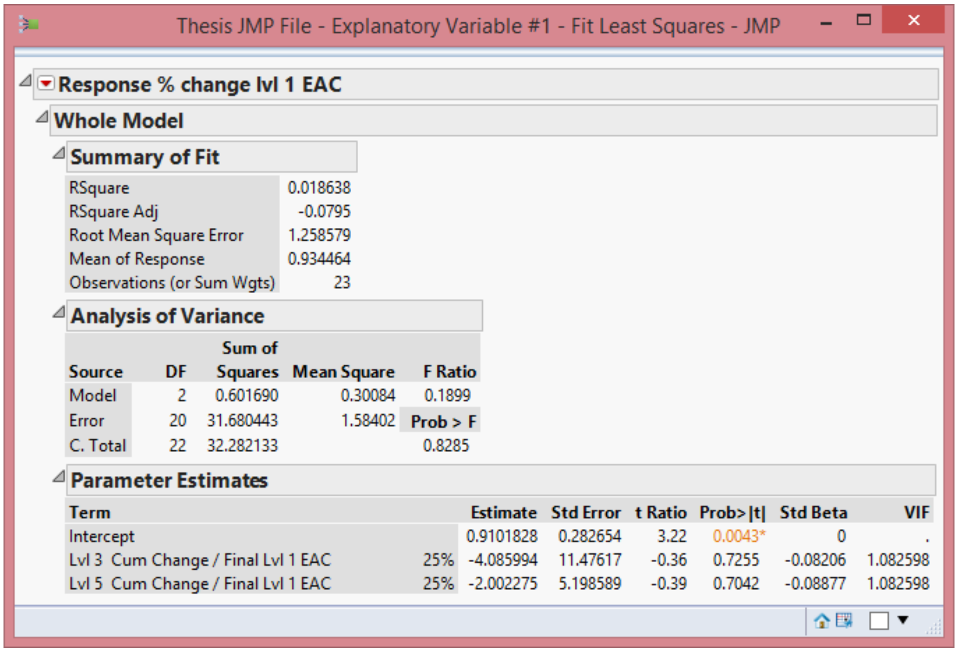
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	2.922906	1.46145	0.9416
Error	18	27.937671	1.55209	Prob > F
C. Total	20	30.860578		0.4084

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.9727877	0.279788	3.48	0.0027*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	20%	13.576372	10.75913	1.26	0.2231	0.298844	1.1152221
Lvl 5 Cum Change / Final Lvl 1 EAC	20%	0.385728	3.667533	0.11	0.9174	0.024908	1.1152221



Growth Definition #1 Bin - 25%



Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

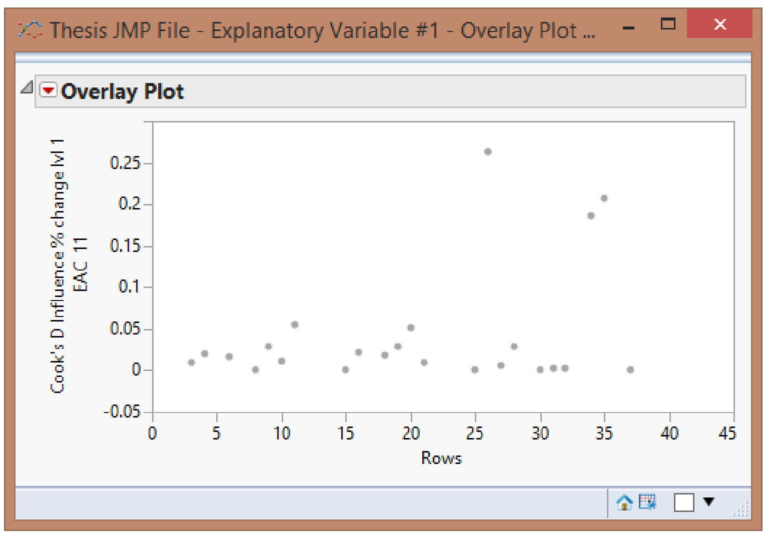
RSquare	0.018638
RSquare Adj	-0.0795
Root Mean Square Error	1.258579
Mean of Response	0.934464
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.601690	0.30084	0.1899
Error	20	31.680443	1.58402	Prob > F
C. Total	22	32.282133		0.8285

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.9101828	0.282654	3.22	0.0043*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	25%	-4.085994	11.47617	-0.36	0.7255	-0.08206	1.082598
Lvl 5 Cum Change / Final Lvl 1 EAC	25%	-2.002275	5.198589	-0.39	0.7042	-0.08877	1.082598



Growth Definition #1 Bin – 30%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

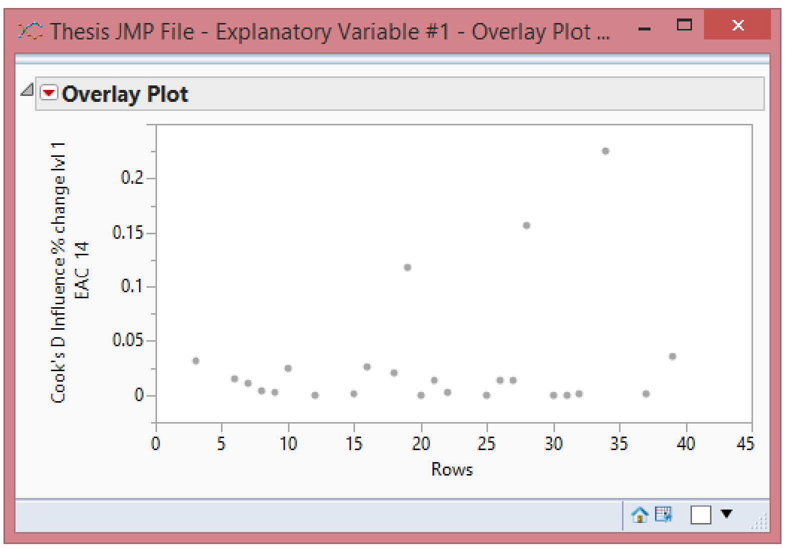
RSquare	0.032951
RSquare Adj	-0.05915
Root Mean Square Error	1.063596
Mean of Response	0.896248
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.809467	0.40473	0.3578
Error	21	23.755950	1.13124	Prob > F
C. Total	23	24.565417		0.7034

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.0364477	0.282625	3.67	0.0014*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	30%	-4.704643	15.54752	-0.30	0.7652	-0.07468	1.3228289
Lvl 5 Cum Change / Final Lvl 1 EAC	30%	-4.233433	7.878684	-0.54	0.5967	-0.13262	1.3228289



Growth Definition #1 Bin - 35%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

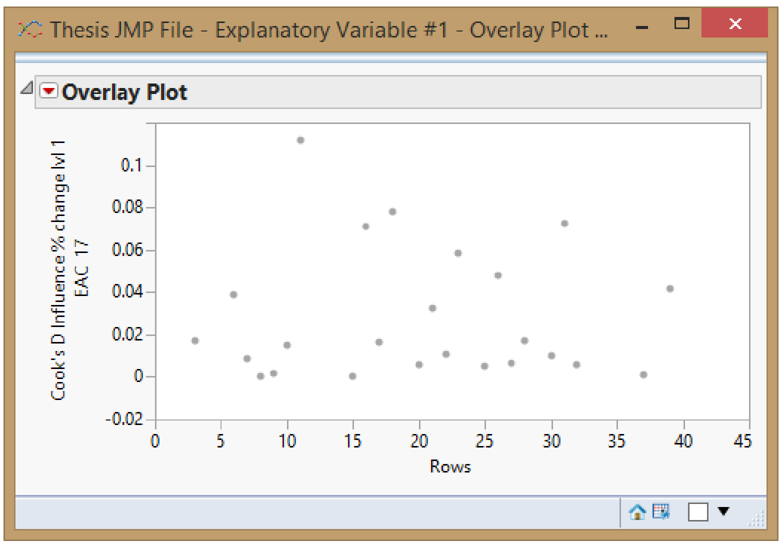
RSquare	0.058247
RSquare Adj	-0.03144
Root Mean Square Error	0.711557
Mean of Response	0.705458
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.657624	0.328812	0.6494
Error	21	10.632571	0.506313	Prob > F
C. Total	23	11.290196		0.5325

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7444813	0.150181	4.96	<.0001*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	35%	-5.114099	7.262316	-0.70	0.4890	-0.15685	1.106269
Lvl 5 Cum Change / Final Lvl 1 EAC	35%	-2.088031	3.295	-0.63	0.5331	-0.14115	1.106269



Growth Definition #1 Bin - 40%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

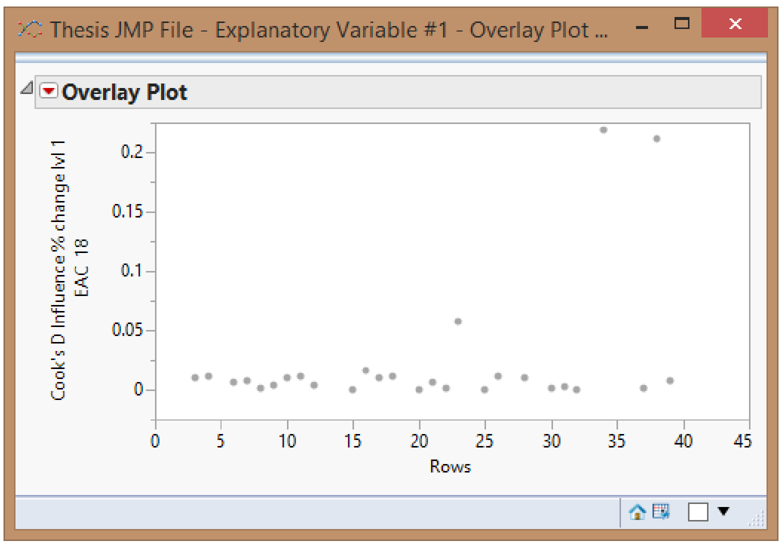
RSquare	0.159495
RSquare Adj	0.089453
Root Mean Square Error	1.279345
Mean of Response	1.002428
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	7.454084	3.72704	2.2771
Error	24	39.281357	1.63672	Prob > F
C. Total	26	46.735441		0.1243

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.9305229	0.261716	3.56	0.0016*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	40%	4.4692465	2.232984	2.00	0.0568	0.390683	1.087985
Lvl 5 Cum Change / Final Lvl 1 EAC	40%	-3.538013	2.765946	-1.28	0.2131	-0.24968	1.087985



Growth Definition #1 Bin - 45%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

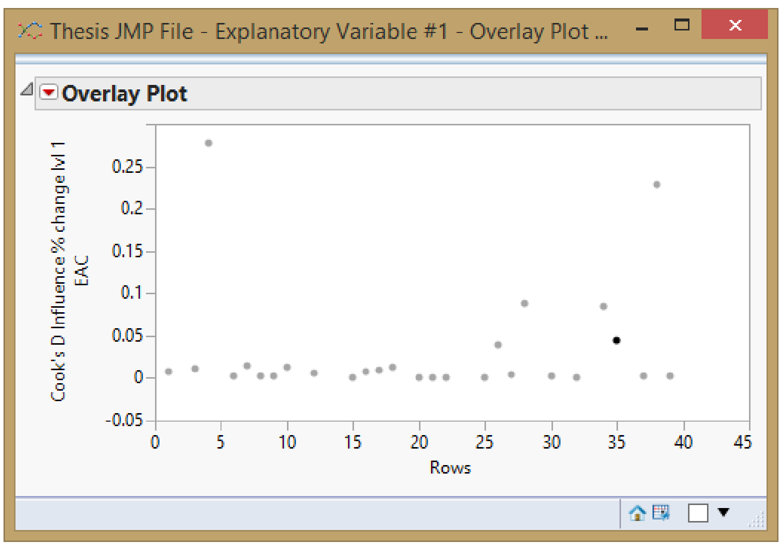
RSquare	0.097554
RSquare Adj	0.02235
Root Mean Square Error	1.405763
Mean of Response	1.141004
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	5.126937	2.56347	1.2972
Error	24	47.428043	1.97617	Prob > F
C. Total	26	52.554980		0.2918

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.2981225	0.287868	4.51	0.0001*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	45%	2.4373436	2.568943	0.95	0.3522	0.221735	1.4525573
Lvl 5 Cum Change / Final Lvl 1 EAC	45%	-6.509016	4.04396	-1.61	0.1206	-0.37617	1.4525573



Growth Definition #1 Bin - 50%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

RSquare	0.00382
RSquare Adj	-0.08674
Root Mean Square Error	1.067048
Mean of Response	0.834367
Observations (or Sum Wgts)	25

Analysis of Variance

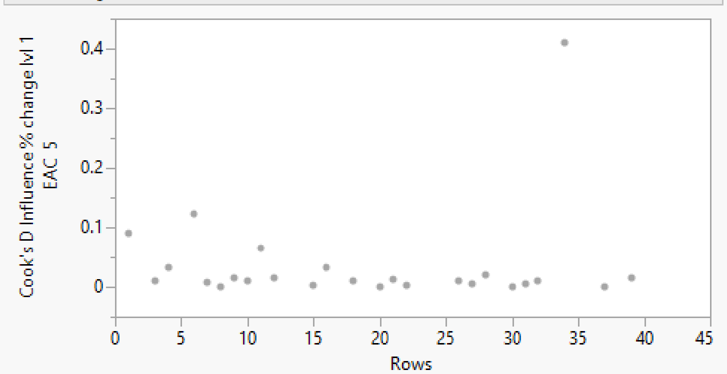
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.096054	0.04803	0.0422
Error	22	25.049014	1.13859	Prob > F
C. Total	24	25.145068		0.9588

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.8693113	0.254186	3.42	0.0025*	0	.
Lvl 5 Cum Change / Final Lvl 1 EAC	50%	0.9807659	3.751154	0.26	0.7962	0.064378	1.3389498
Lvl 3 Cum Change / Final Lvl 1 EAC	50%	-3.030836	12.5829	-0.24	0.8119	-0.05931	1.3389498

Thesis JMP File - Explanatory Variable #1 - Overlay Plot ...

Overlay Plot



Growth Definition #1 Bin - 55%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

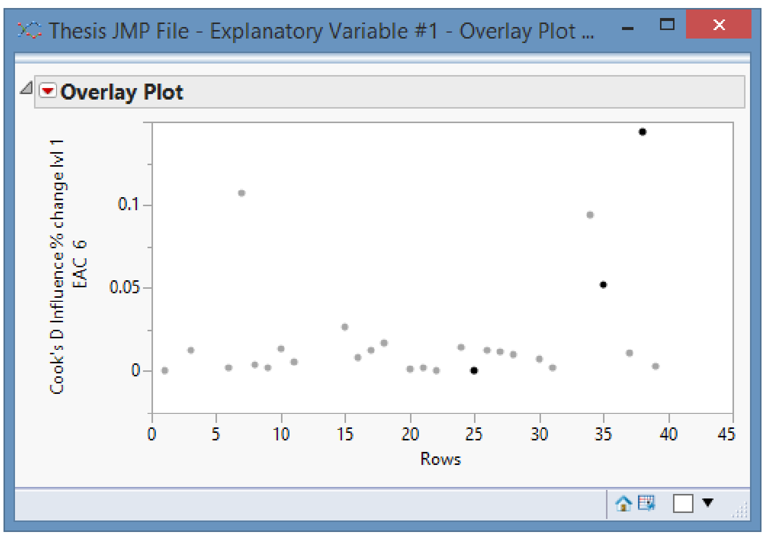
RSquare	0.064663
RSquare Adj	-0.01328
Root Mean Square Error	1.441062
Mean of Response	1.108669
Observations (or Sum Wgts)	27

Analysis of Variance

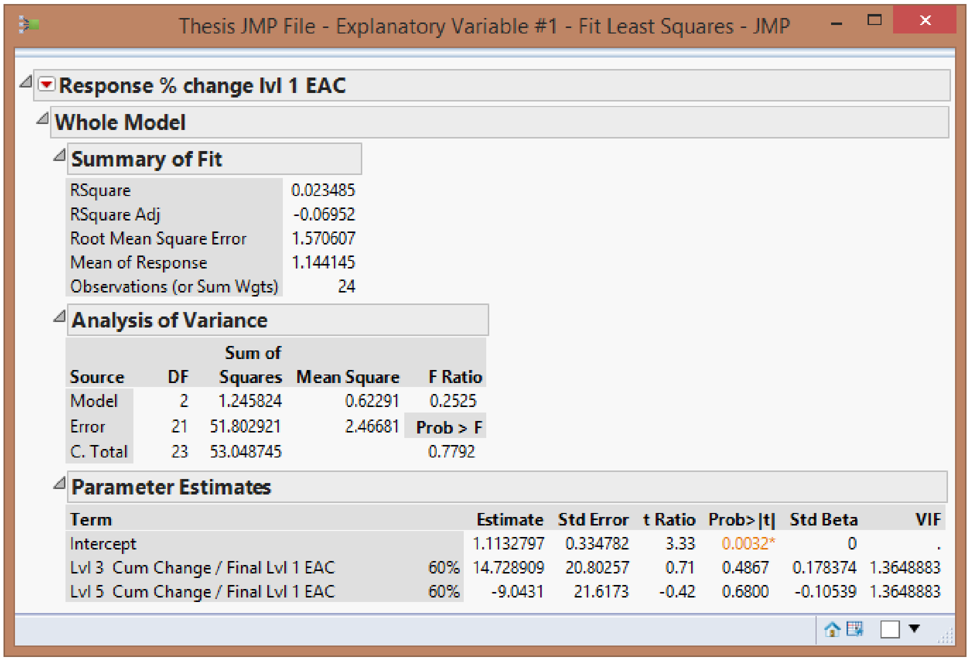
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	3.445605	1.72280	0.8296
Error	24	49.839842	2.07666	Prob > F
C. Total	26	53.285448		0.4483

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.2927478	0.320705	4.03	0.0005*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	55%	-0.122451	7.731061	-0.02	0.9875	-0.00352	1.2703243
Lvl 5 Cum Change / Final Lvl 1 EAC	55%	7.8621345	6.836167	1.15	0.2614	0.255896	1.2703243



Growth Definition #1 Bin - 60%



Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

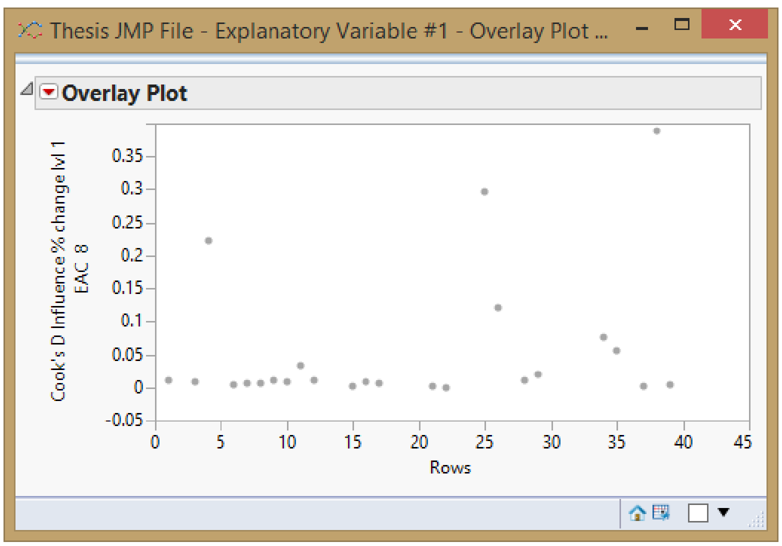
RSquare	0.023485
RSquare Adj	-0.06952
Root Mean Square Error	1.570607
Mean of Response	1.144145
Observations (or Sum Wgts)	24

Analysis of Variance

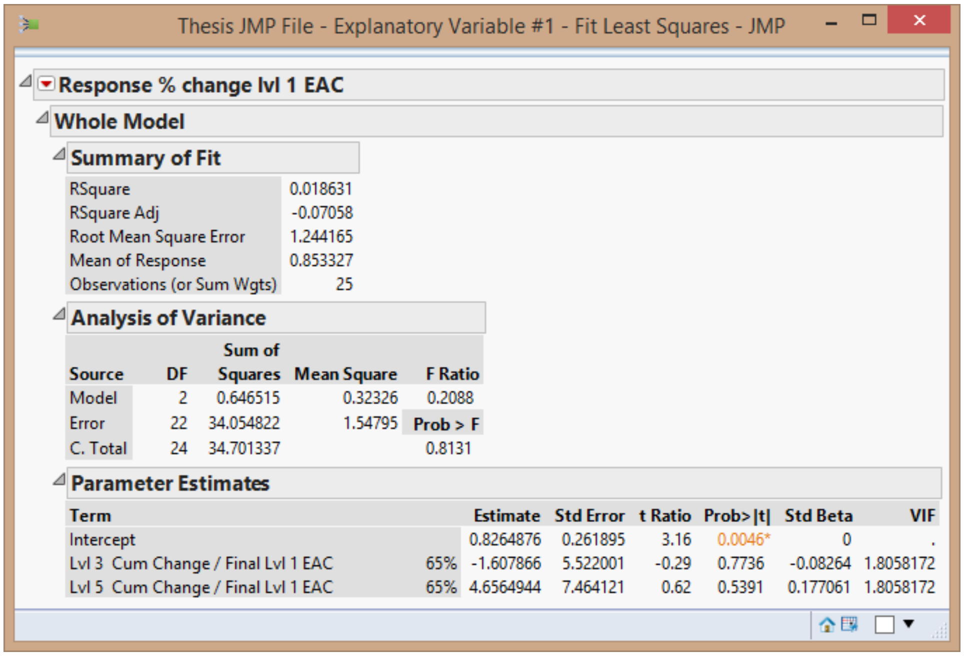
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	1.245824	0.62291	0.2525
Error	21	51.802921	2.46681	Prob > F
C. Total	23	53.048745		0.7792

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.1132797	0.334782	3.33	0.0032*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	60%	14.728909	20.80257	0.71	0.4867	0.178374	1.3648883
Lvl 5 Cum Change / Final Lvl 1 EAC	60%	-9.0431	21.6173	-0.42	0.6800	-0.10539	1.3648883



Growth Definition #1 Bin - 65%



Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

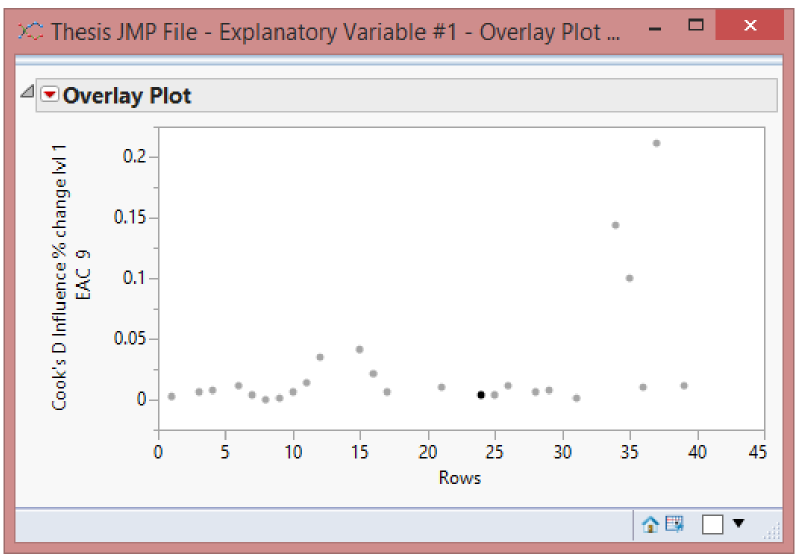
RSquare	0.018631
RSquare Adj	-0.07058
Root Mean Square Error	1.244165
Mean of Response	0.853327
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.646515	0.32326	0.2088
Error	22	34.054822	1.54795	Prob > F
C. Total	24	34.701337		0.8131

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.8264876	0.261895	3.16	0.0046*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	65%	-1.607866	5.522001	-0.29	0.7736	-0.08264	1.8058172
Lvl 5 Cum Change / Final Lvl 1 EAC	65%	4.6564944	7.464121	0.62	0.5391	0.177061	1.8058172



Growth Definition #1 Bin - 70%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

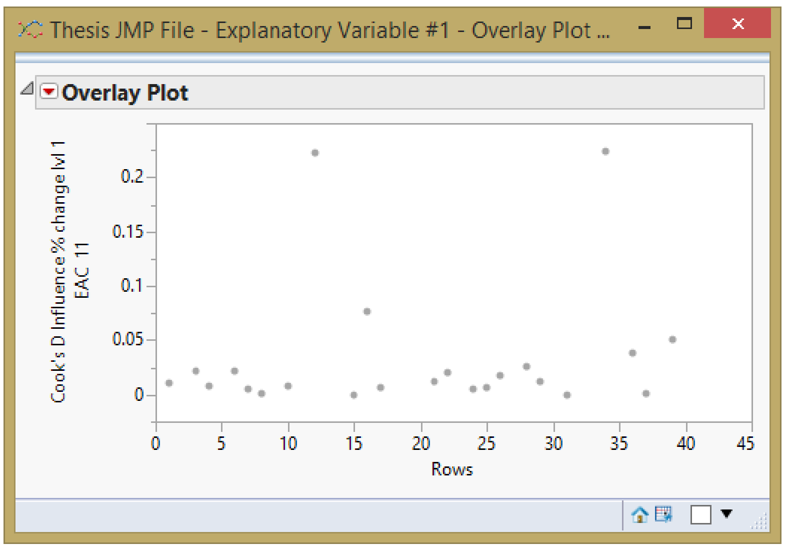
RSquare	0.034704
RSquare Adj	-0.06183
Root Mean Square Error	1.113118
Mean of Response	0.802937
Observations (or Sum Wgts)	23

Analysis of Variance

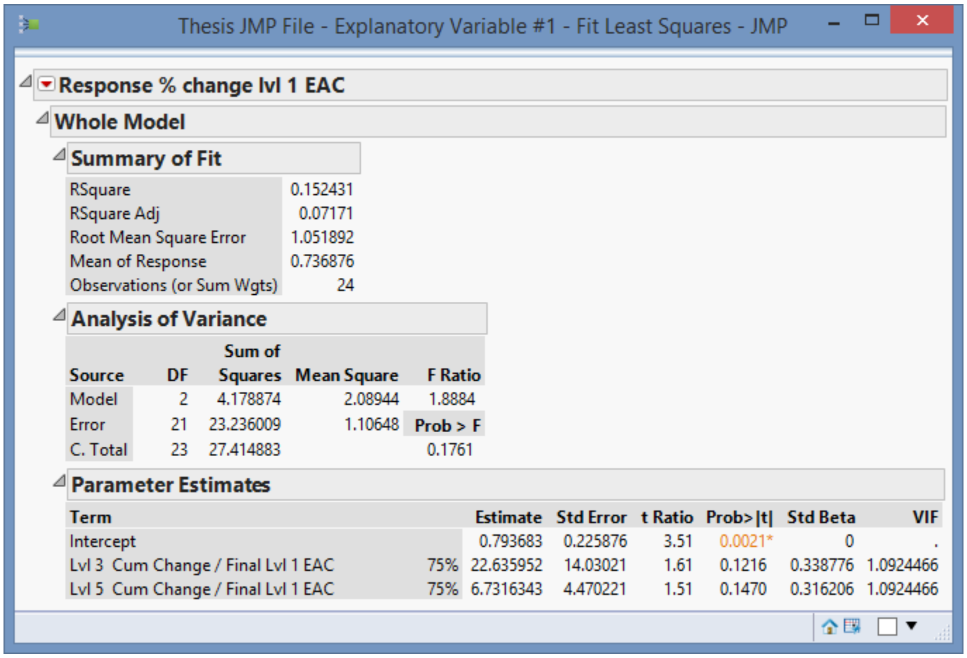
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.890912	0.44546	0.3595
Error	20	24.780655	1.23903	Prob > F
C. Total	22	25.671568		0.7024

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.753988	0.264025	2.86	0.0098*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	70%	11.480725	14.23118	0.81	0.4293	0.18525	1.092525
Lvl 5 Cum Change / Final Lvl 1 EAC	70%	-6.956582	14.35344	-0.48	0.6332	-0.11129	1.092525



Growth Definition #1 Bin - 75%



Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

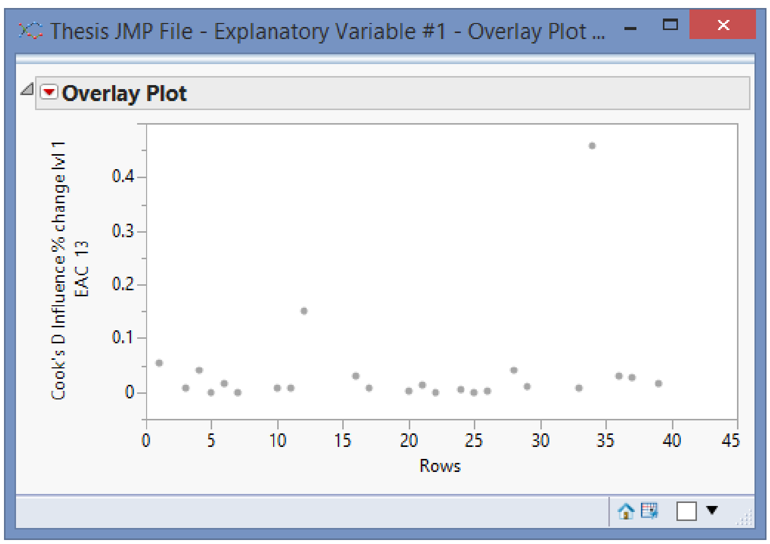
RSquare	0.152431
RSquare Adj	0.07171
Root Mean Square Error	1.051892
Mean of Response	0.736876
Observations (or Sum Wgts)	24

Analysis of Variance

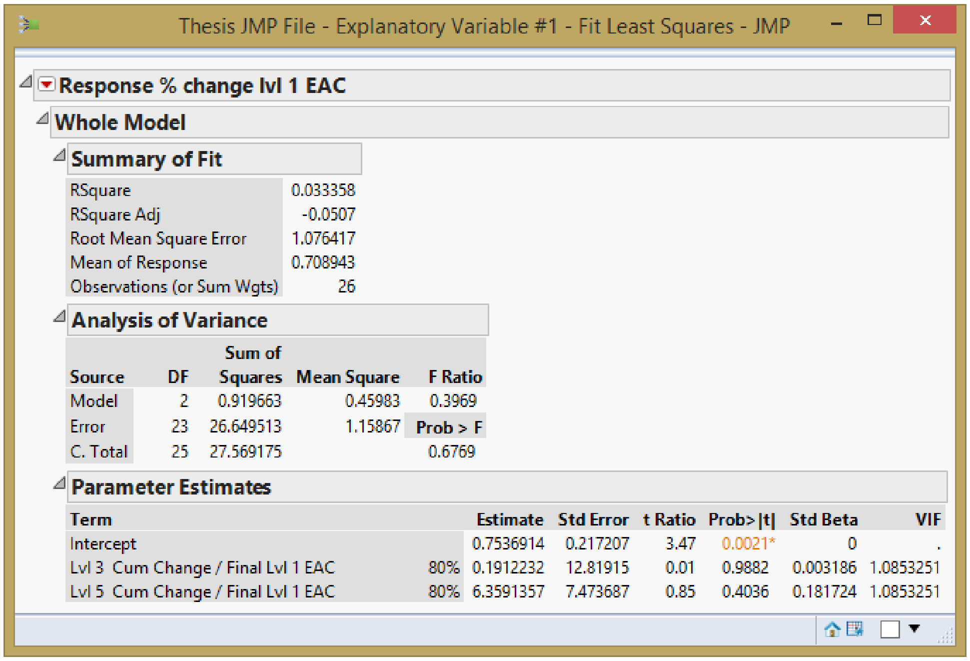
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	4.178874	2.08944	1.8884
Error	21	23.236009	1.10648	Prob > F
C. Total	23	27.414883		0.1761

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.793683	0.225876	3.51	0.0021*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	75%	22.635952	14.03021	1.61	0.1216	0.338776	1.0924466
Lvl 5 Cum Change / Final Lvl 1 EAC	75%	6.7316343	4.470221	1.51	0.1470	0.316206	1.0924466



Growth Definition #1 Bin - 80%



Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

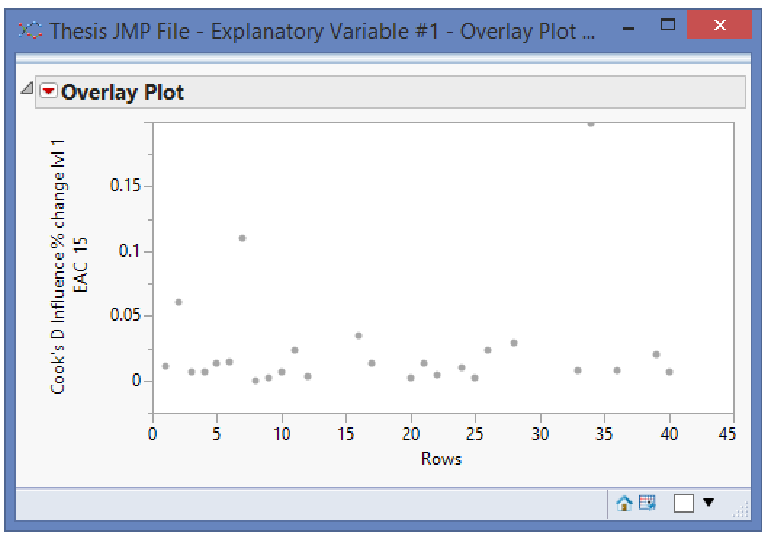
RSquare	0.033358
RSquare Adj	-0.0507
Root Mean Square Error	1.076417
Mean of Response	0.708943
Observations (or Sum Wgts)	26

Analysis of Variance

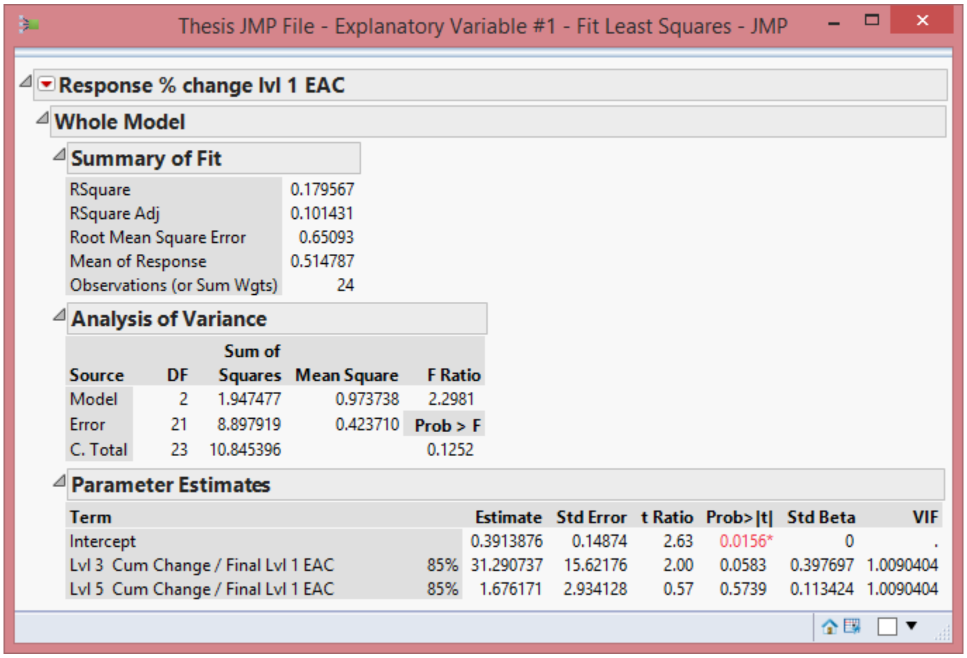
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.919663	0.45983	0.3969
Error	23	26.649513	1.15867	Prob > F
C. Total	25	27.569175		0.6769

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7536914	0.217207	3.47	0.0021*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	80%	0.1912232	12.81915	0.01	0.9882	0.003186	1.0853251
Lvl 5 Cum Change / Final Lvl 1 EAC	80%	6.3591357	7.473687	0.85	0.4036	0.181724	1.0853251



Growth Definition #1 Bin - 85%



Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

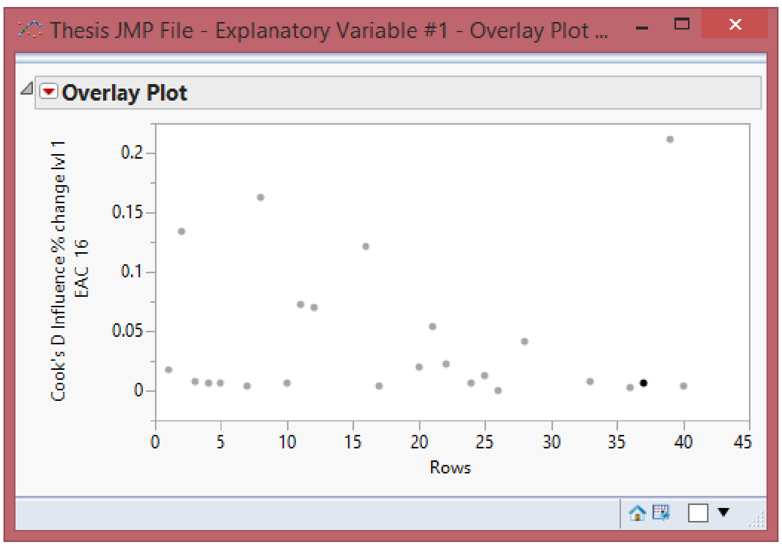
RSquare	0.179567
RSquare Adj	0.101431
Root Mean Square Error	0.65093
Mean of Response	0.514787
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	1.947477	0.973738	2.2981
Error	21	8.897919	0.423710	Prob > F
C. Total	23	10.845396		0.1252

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.3913876	0.14874	2.63	0.0156*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	85%	31.290737	15.62176	2.00	0.0583	0.397697	1.0090404
Lvl 5 Cum Change / Final Lvl 1 EAC	85%	1.676171	2.934128	0.57	0.5739	0.113424	1.0090404



Growth Definition #1 Bin - 90%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

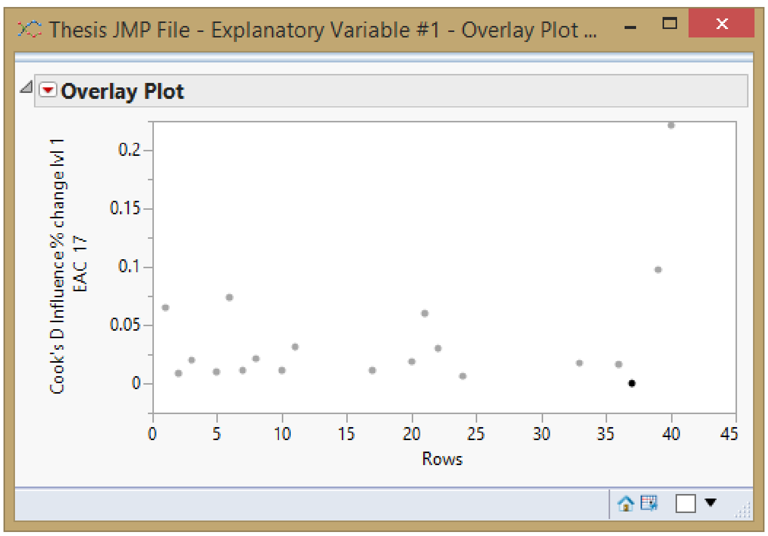
RSquare	0.034002
RSquare Adj	-0.08675
Root Mean Square Error	0.709484
Mean of Response	0.543857
Observations (or Sum Wgts)	19

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.2834857	0.141743	0.2816
Error	16	8.0538877	0.503368	Prob > F
C. Total	18	8.3373734		0.7582

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.6089155	0.19237	3.17	0.0060*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	90%	-8.791475	16.74361	-0.53	0.6067	-0.12991	1.0138836
Lvl 5 Cum Change / Final Lvl 1 EAC	90%	3.7972964	6.393452	0.59	0.5609	0.146947	1.0138836



Growth Definition #1 Bin - 95%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

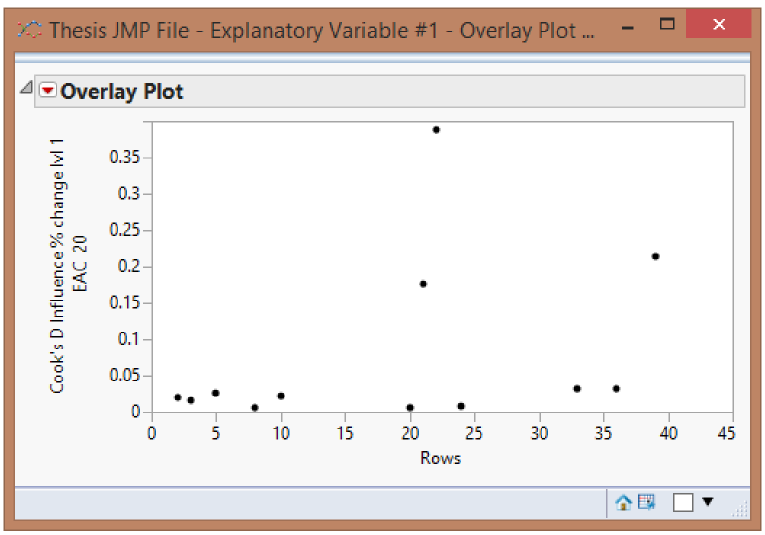
RSquare	0.19763
RSquare Adj	0.117393
Root Mean Square Error	0.679486
Mean of Response	0.597092
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.1372079	1.13721	2.4631
Error	10	4.6170103	0.46170	Prob > F
C. Total	11	5.7542182		0.1476

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.4520637	0.216828	2.08	0.0637	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	95%	26.412663	16.82956	1.57	0.1476	0.444556	1



Growth Definition #1 Bin - 100%

Thesis JMP File - Explanatory Variable #1 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

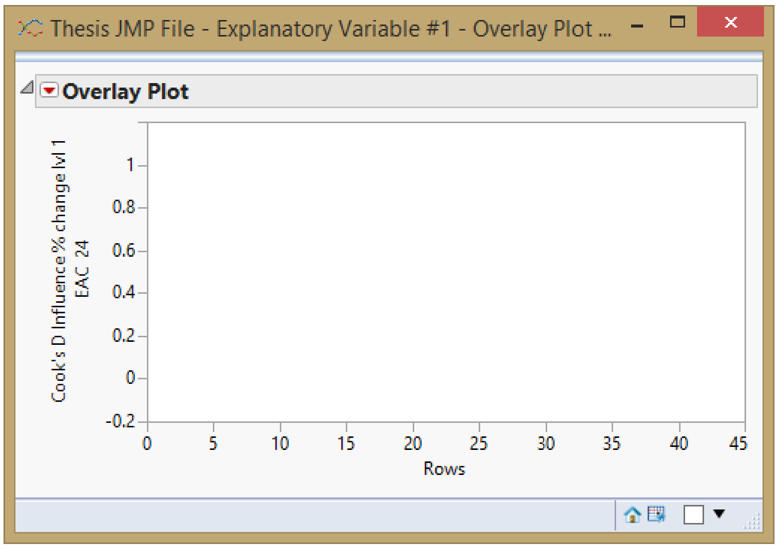
Actual by Predicted Plot

Summary of Fit

RSquare	1
RSquare Adj	.
Root Mean Square Error	.
Mean of Response	-0.01071
Observations (or Sum Wgts)	3

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.038004	.	.	.	.	.
Lvl 3 Cum Change / Final Lvl 1 EAC	100%	-4.929009	.	.	.	.	20.819065
Lvl 5 Cum Change / Final Lvl 1 EAC	100%	-7.77093	.	.	.	.	20.819065



Appendix E - JMP® Output Screens for Growth Definition #2

Growth Definition #2 Bin - 5%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

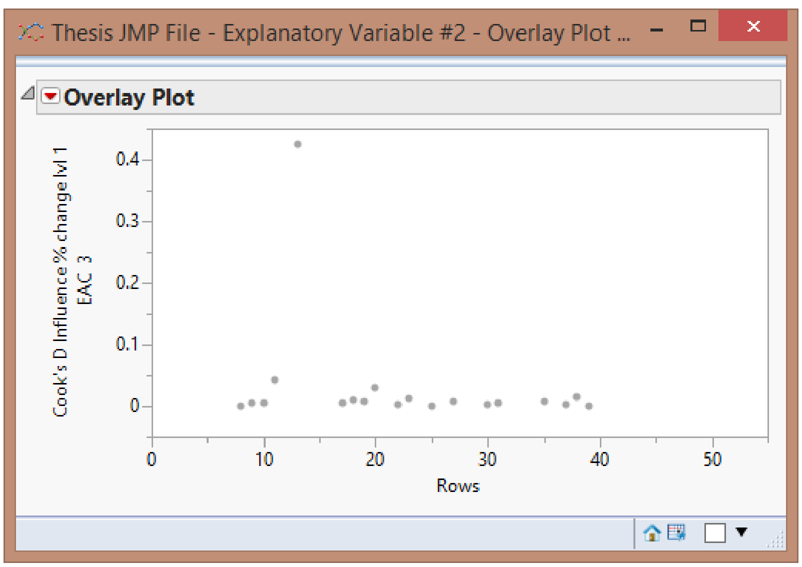
RSquare	0.002261
RSquare Adj	-0.05643
Root Mean Square Error	2.97745
Mean of Response	1.331519
Observations (or Sum Wgts)	19

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.34157	0.34157	0.0385
Error	17	150.70850	8.86521	Prob > F
C. Total	18	151.05006		0.8467

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.3660809	0.705403	1.94	0.0696	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	5%	-5.495137	27.99528	-0.20	0.8467	-0.04755	1



Growth Definition #2 Bin - 10%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

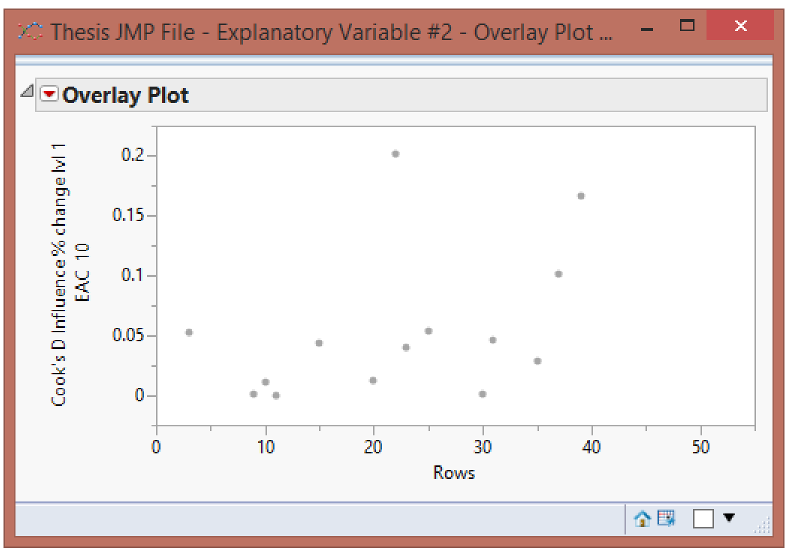
RSquare	0.271891
RSquare Adj	0.211215
Root Mean Square Error	0.653282
Mean of Response	0.630348
Observations (or Sum Wgts)	14

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.9124051	1.91241	4.4810
Error	12	5.1213206	0.42678	Prob > F
C. Total	13	7.0337257		0.0558

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7373027	0.18176	4.06	0.0016*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	10%	305.07777	144.1189	2.12	0.0558	0.521431	1



Growth Definition #2 Bin - 15%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

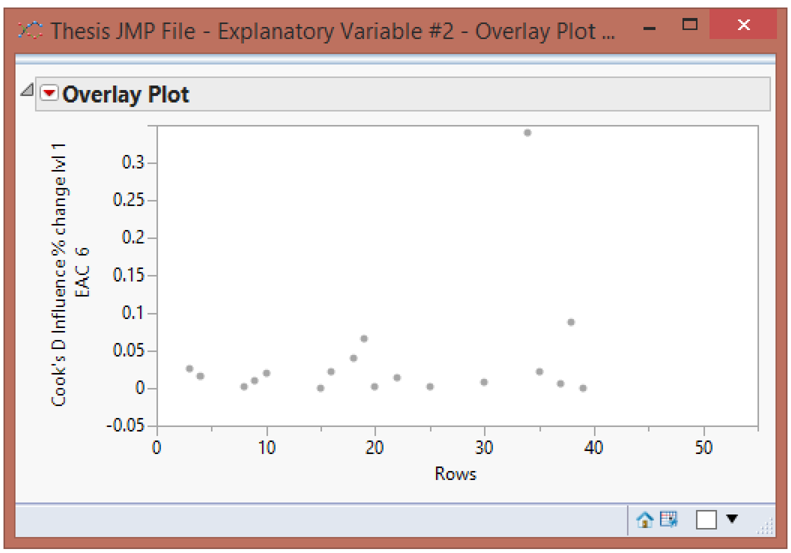
RSquare	0.072469
RSquare Adj	0.014499
Root Mean Square Error	1.267988
Mean of Response	1.121158
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.009913	2.00991	1.2501
Error	16	25.724713	1.60779	Prob > F
C. Total	17	27.734626		0.2800

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.0401498	0.307524	3.38	0.0038*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	15%	32.357764	28.94044	1.12	0.2800	0.269201	1



Growth Definition #2 Bin - 20%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

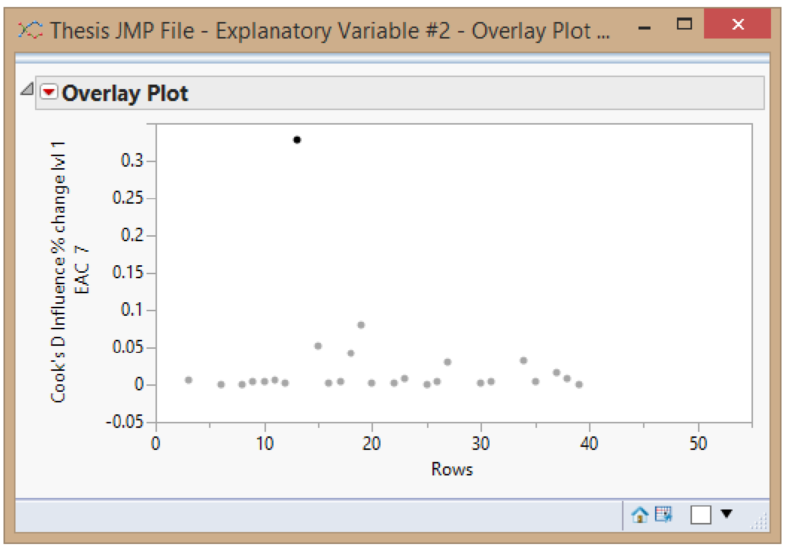
RSquare	0.030431
RSquare Adj	-0.05388
Root Mean Square Error	2.652541
Mean of Response	1.359358
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	5.07908	2.53954	0.3609
Error	23	161.82744	7.03598	Prob > F
C. Total	25	166.90652		0.7009

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.287574	0.586587	2.20	0.0385*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	20%	8.227718	55.09646	0.15	0.8826	0.031798	1.0755671
Lvl 5 Cum Change / Final Lvl 1 EAC	20%	34.054685	44.40537	0.77	0.4509	0.1633	1.0755671



Growth Definition #2 Bin - 25%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

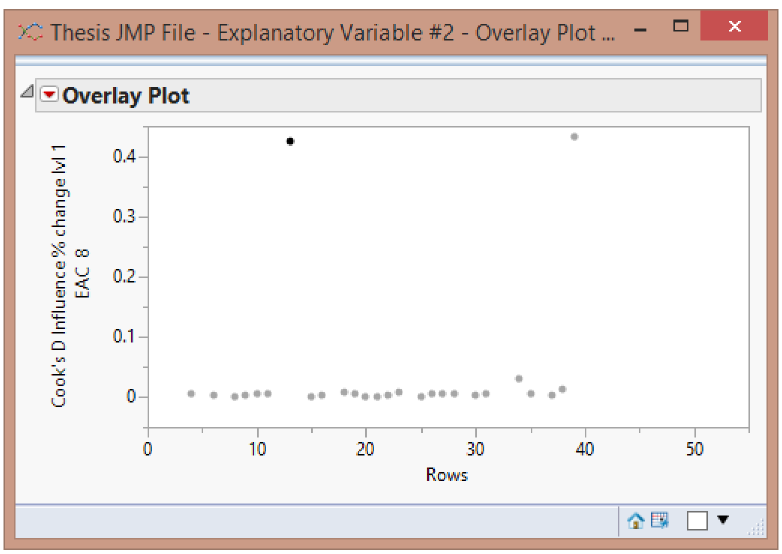
RSquare	0.005493
RSquare Adj	-0.03594
Root Mean Square Error	2.619945
Mean of Response	1.402769
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.90996	0.90996	0.1326
Error	24	164.73865	6.86411	Prob > F
C. Total	25	165.64861		0.7190

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.3484875	0.535005	2.52	0.0188*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	25%	4.1064873	11.27851	0.36	0.7190	0.074117	1



Growth Definition #2 Bin – 30%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

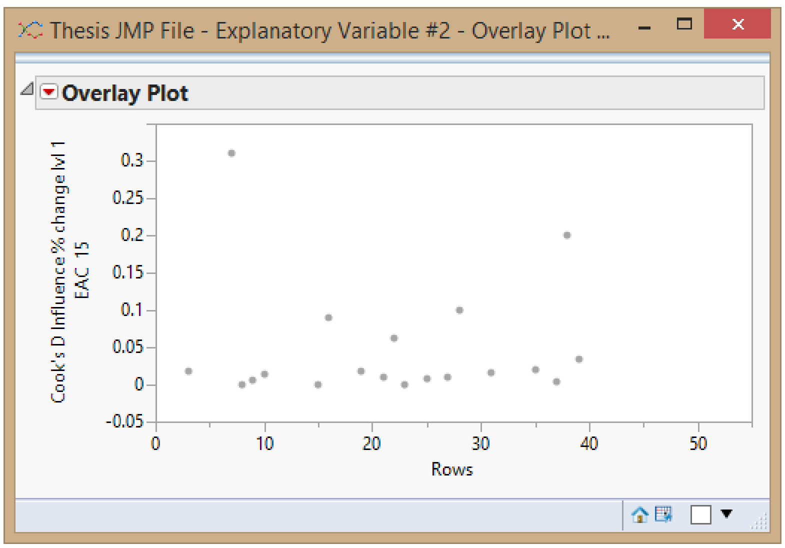
RSquare	0.105754
RSquare Adj	0.053151
Root Mean Square Error	0.946045
Mean of Response	0.81337
Observations (or Sum Wgts)	19

Analysis of Variance

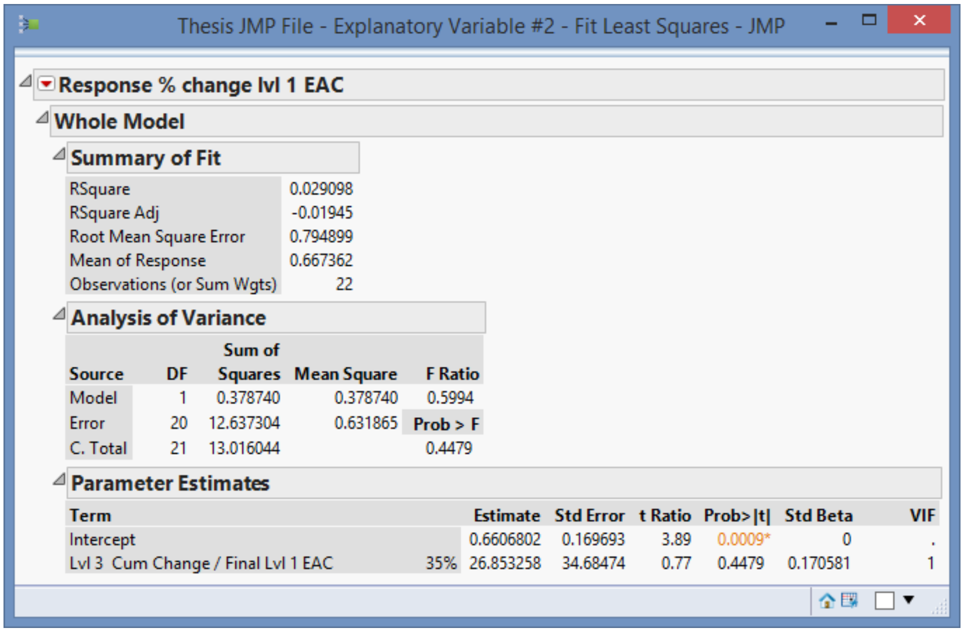
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.799333	1.79933	2.0104
Error	17	15.215019	0.89500	Prob > F
C. Total	18	17.014352		0.1743

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7658766	0.219607	3.49	0.0028*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	30%	148.11858	104.4637	1.42	0.1743	0.325198	1



Growth Definition #2 Bin - 35%



Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

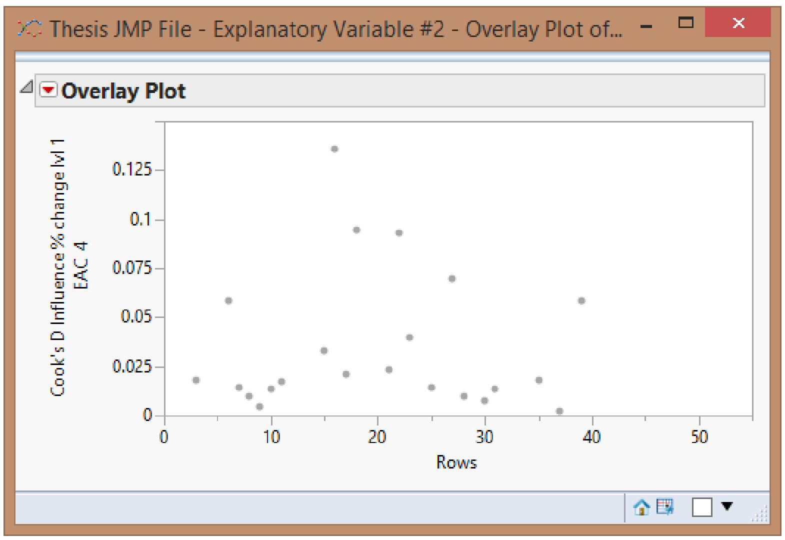
RSquare	0.029098
RSquare Adj	-0.01945
Root Mean Square Error	0.794899
Mean of Response	0.667362
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.378740	0.378740	0.5994
Error	20	12.637304	0.631865	Prob > F
C. Total	21	13.016044		0.4479

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.6606802	0.169693	3.89	0.0009*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	35%	26.853258	34.68474	0.77	0.4479	0.170581	1



Growth Definition #2 Bin - 40%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

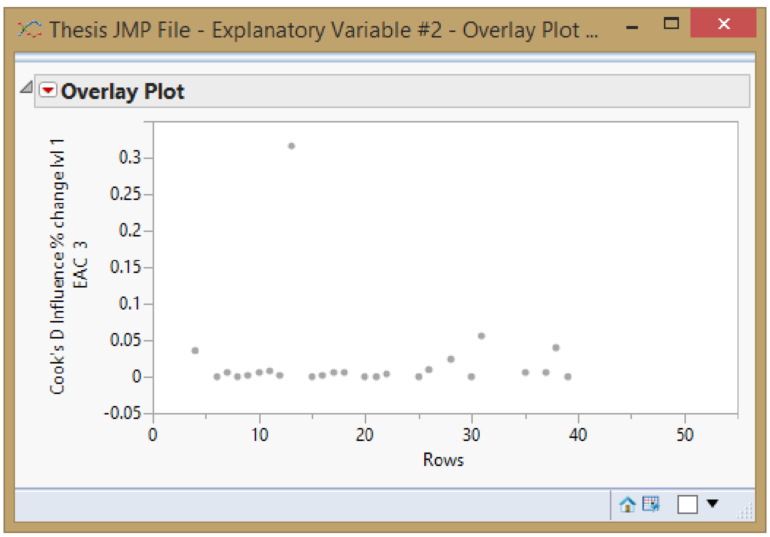
RSquare	0.015432
RSquare Adj	-0.07407
Root Mean Square Error	2.624616
Mean of Response	1.298861
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	2.37541	1.18771	0.1724
Error	22	151.54934	6.88861	Prob > F
C. Total	24	153.92476		0.8428

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.3960055	0.575352	2.43	0.0239*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	40%	-44.3881	115.3754	-0.38	0.7041	-0.09653	1.4066069
Lvl 5 Cum Change / Final Lvl 1 EAC	40%	45.980598	79.15234	0.58	0.5672	0.14575	1.4066069



Growth Definition #2 Bin - 45%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

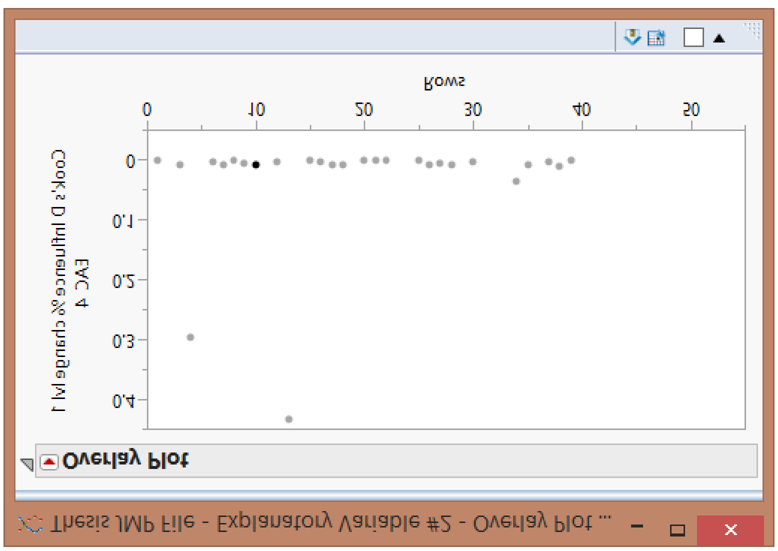
RSquare	0.014753
RSquare Adj	-0.02466
Root Mean Square Error	2.542078
Mean of Response	1.450348
Observations (or Sum Wgts)	27

Analysis of Variance

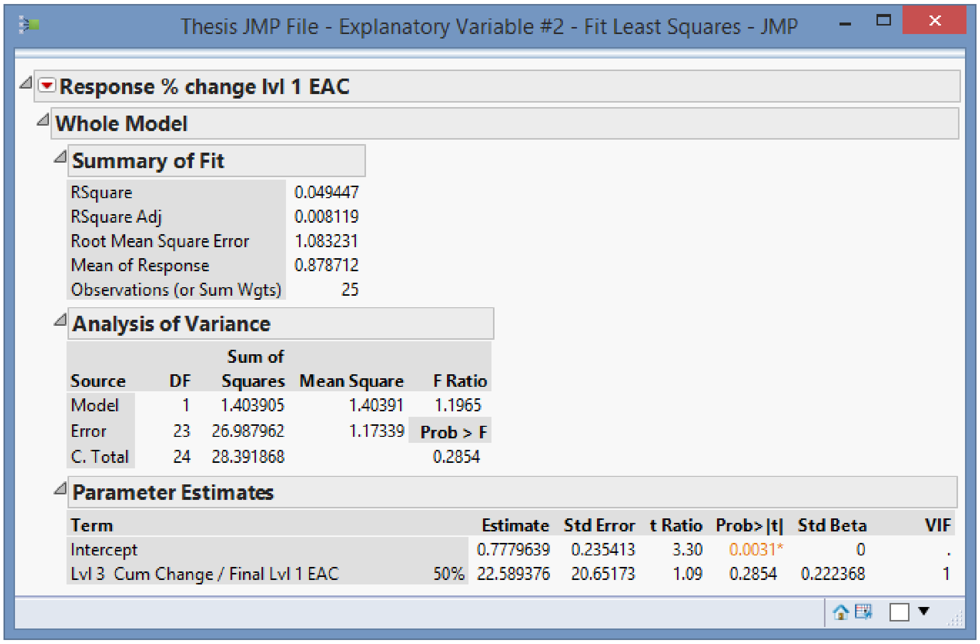
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.41917	2.41917	0.3744
Error	25	161.55402	6.46216	Prob > F
C. Total	26	163.97319		0.5462

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.5497789	0.515508	3.01	0.0059*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	45%	-3.968102	6.485422	-0.61	0.5462	-0.12146	1



Growth Definition #2 Bin - 50%



Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

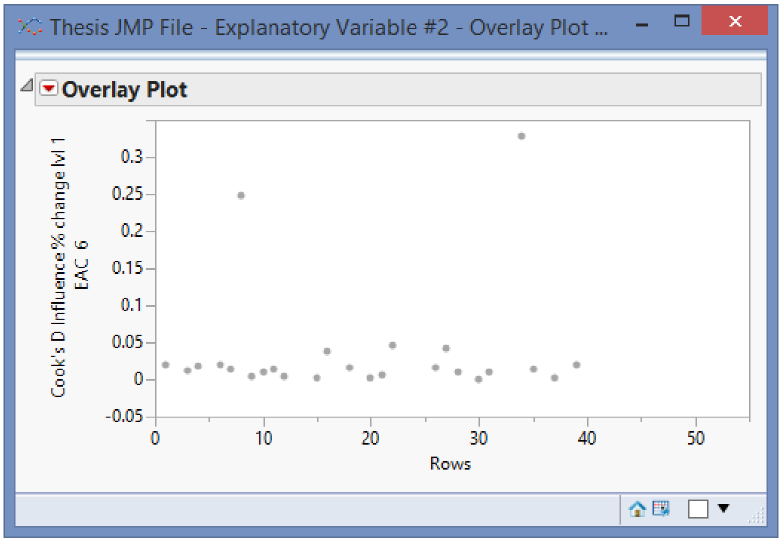
RSquare	0.049447
RSquare Adj	0.008119
Root Mean Square Error	1.083231
Mean of Response	0.878712
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.403905	1.40391	1.1965
Error	23	26.987962	1.17339	Prob > F
C. Total	24	28.391868		0.2854

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7779639	0.235413	3.30	0.0031*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	50%	22.589376	20.65173	1.09	0.2854	0.222368	1



Growth Definition #2 Bin - 55%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

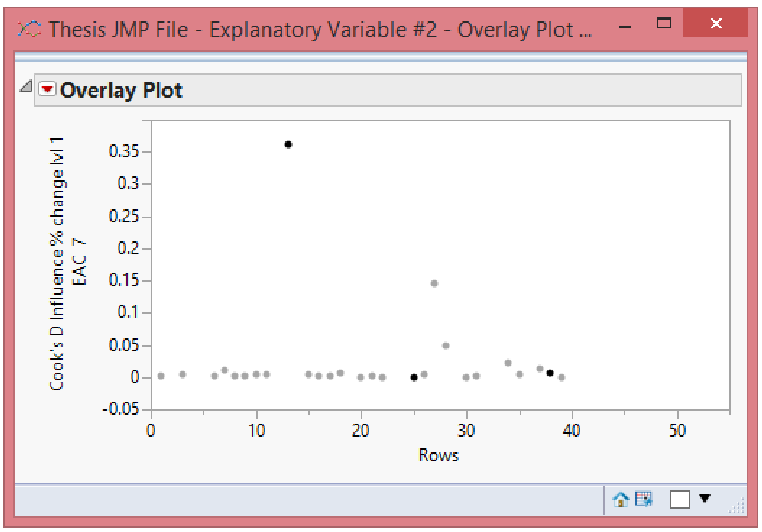
RSquare	0.043954
RSquare Adj	-0.03572
Root Mean Square Error	2.566917
Mean of Response	1.428183
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	7.27037	3.63518	0.5517
Error	24	158.13746	6.58906	Prob > F
C. Total	26	165.40783		0.5831

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.3553421	0.519748	2.61	0.0154*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	55%	-31.16111	42.8089	-0.73	0.4737	-0.21086	2.1065596
Lvl 5 Cum Change / Final Lvl 1 EAC	55%	92.1417	87.80751	1.05	0.3045	0.30398	2.1065596



Growth Definition #2 Bin - 60%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

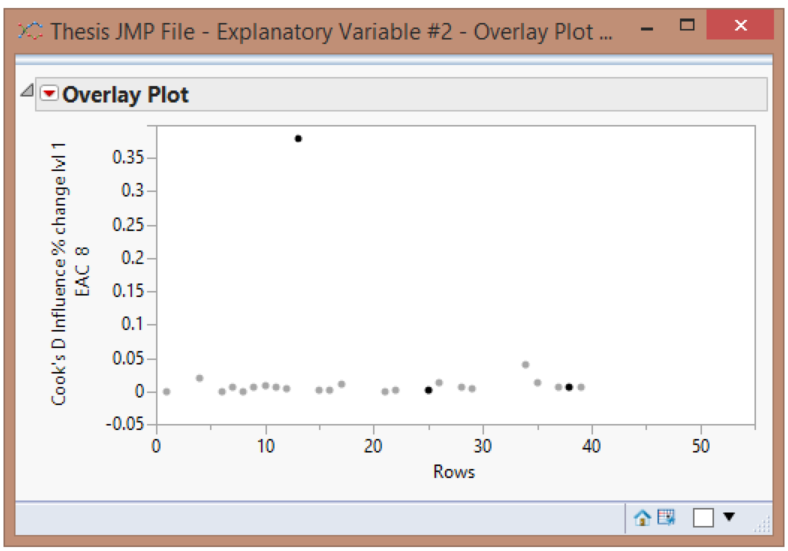
RSquare	0.011253
RSquare Adj	-0.08291
Root Mean Square Error	2.759306
Mean of Response	1.540751
Observations (or Sum Wgts)	24

Analysis of Variance

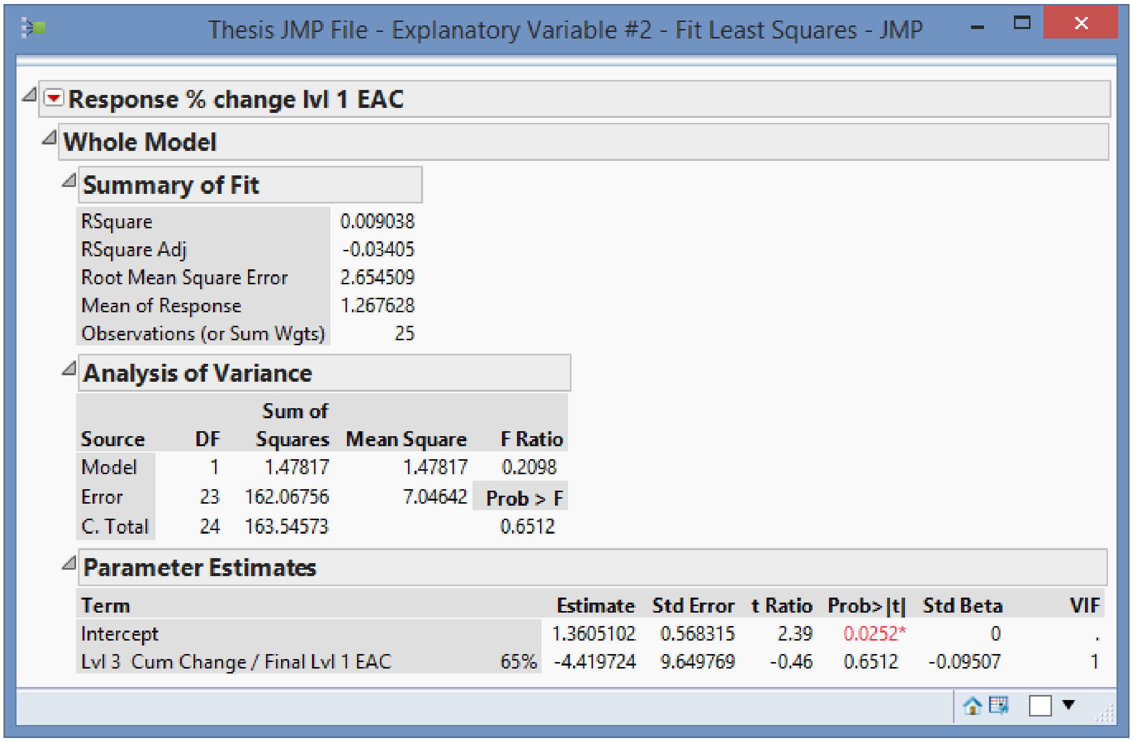
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	1.81978	0.90989	0.1195
Error	21	159.88921	7.61377	Prob > F
C. Total	23	161.70899		0.8880

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.7046792	0.694772	2.45	0.0230*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	60%	-22.21405	50.58082	-0.44	0.6650	-0.10095	1.1221139
Lvl 5 Cum Change / Final Lvl 1 EAC	60%	-0.706584	12.20699	-0.06	0.9544	-0.0133	1.1221139



Growth Definition #2 Bin - 65%



Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

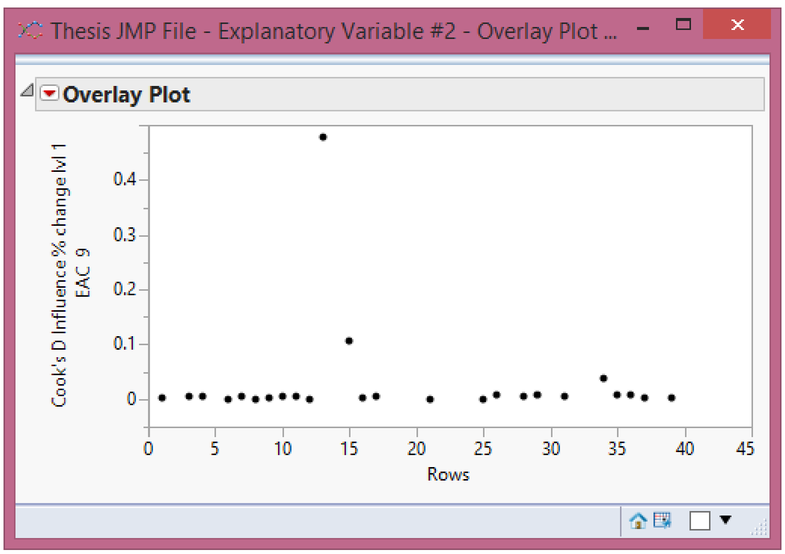
RSquare	0.009038
RSquare Adj	-0.03405
Root Mean Square Error	2.654509
Mean of Response	1.267628
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.47817	1.47817	0.2098
Error	23	162.06756	7.04642	Prob > F
C. Total	24	163.54573		0.6512

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.3605102	0.568315	2.39	0.0252*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	65%	-4.419724	9.649769	-0.46	0.6512	-0.09507	1



Growth Definition #2 Bin - 70%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

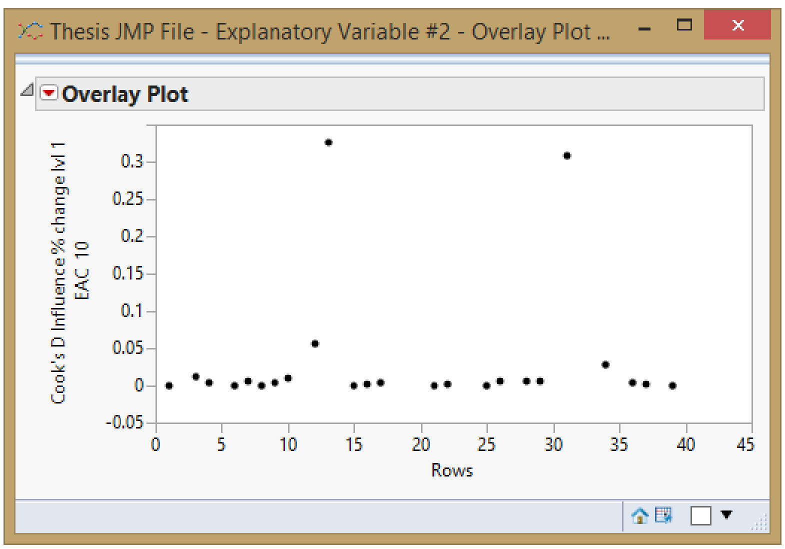
RSquare	0.003963
RSquare Adj	-0.0909
Root Mean Square Error	2.759157
Mean of Response	1.408385
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.63605	0.31803	0.0418
Error	21	159.87194	7.61295	Prob > F
C. Total	23	160.50799		0.9592

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.3173971	0.757824	1.74	0.0968	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	70%	4.0190847	70.73584	0.06	0.9552	0.02398	3.7554605
Lvl 5 Cum Change / Final Lvl 1 EAC	70%	5.9078503	60.54625	0.10	0.9232	0.041181	3.7554605



Growth Definition #2 Bin - 75%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

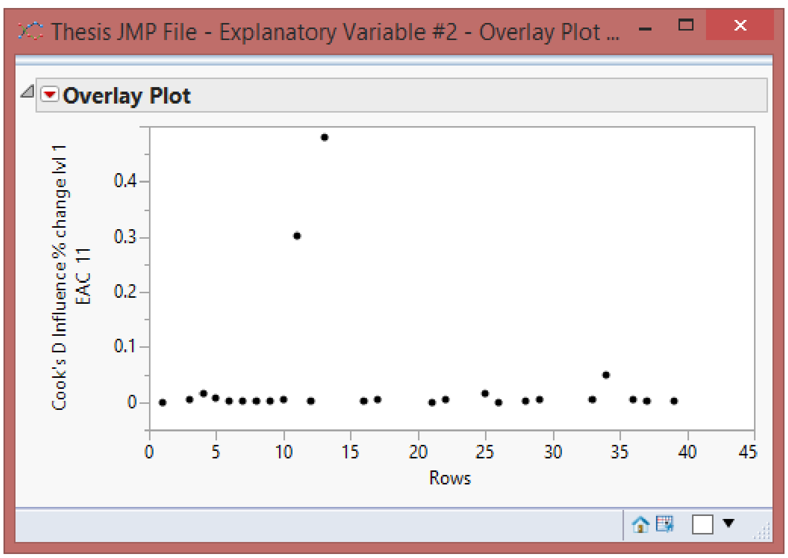
RSquare	0.080927
RSquare Adj	0.040967
Root Mean Square Error	2.558527
Mean of Response	1.321688
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	13.25713	13.2571	2.0252
Error	23	150.55942	6.5461	Prob > F
C. Total	24	163.81654		0.1681

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.2888839	0.512224	2.52	0.0193*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	75%	48.702874	34.22315	1.42	0.1681	0.284476	1



Growth Definition #2 Bin - 80%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

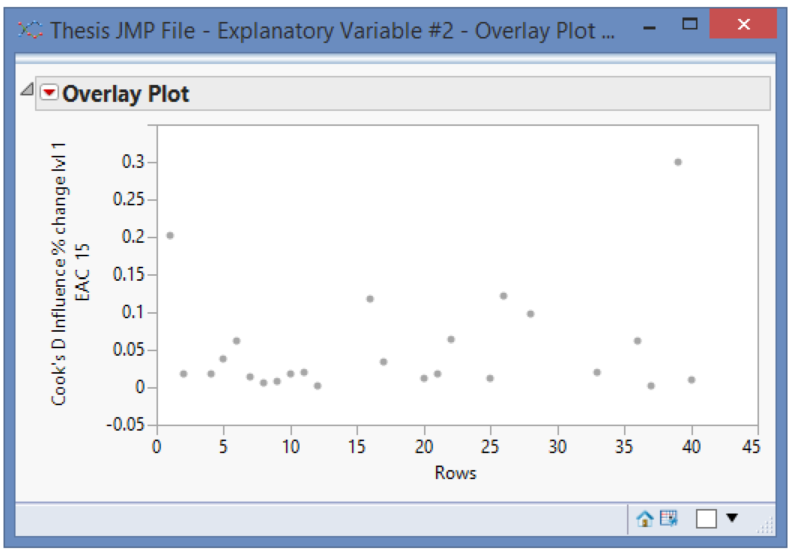
RSquare	0.002549
RSquare Adj	-0.04279
Root Mean Square Error	0.8191
Mean of Response	0.721633
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.037722	0.037722	0.0562
Error	22	14.760339	0.670925	Prob > F
C. Total	23	14.798062		0.8148

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.7430541	0.190043	3.91	0.0008*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	80%	-5.735106	24.1868	-0.24	0.8148	-0.05049	1



Growth Definition #2 Bin - 85%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

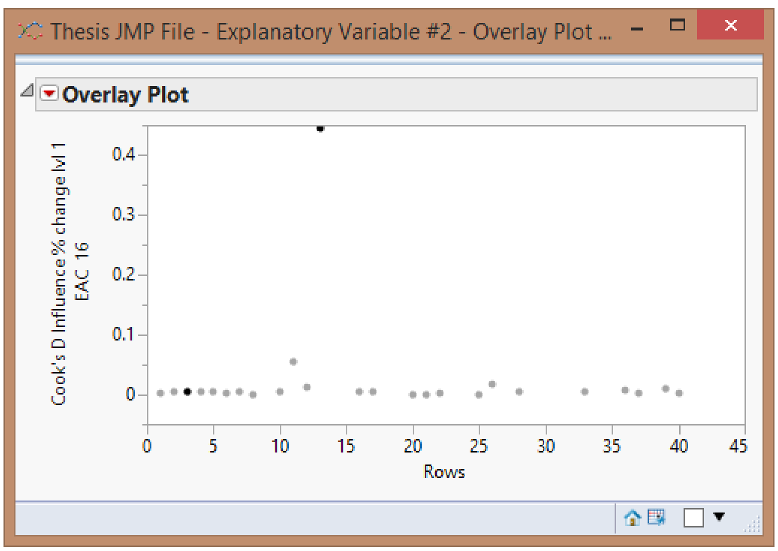
RSquare	0.001908
RSquare Adj	-0.04149
Root Mean Square Error	2.574788
Mean of Response	1.188523
Observations (or Sum Wgts)	25

Analysis of Variance

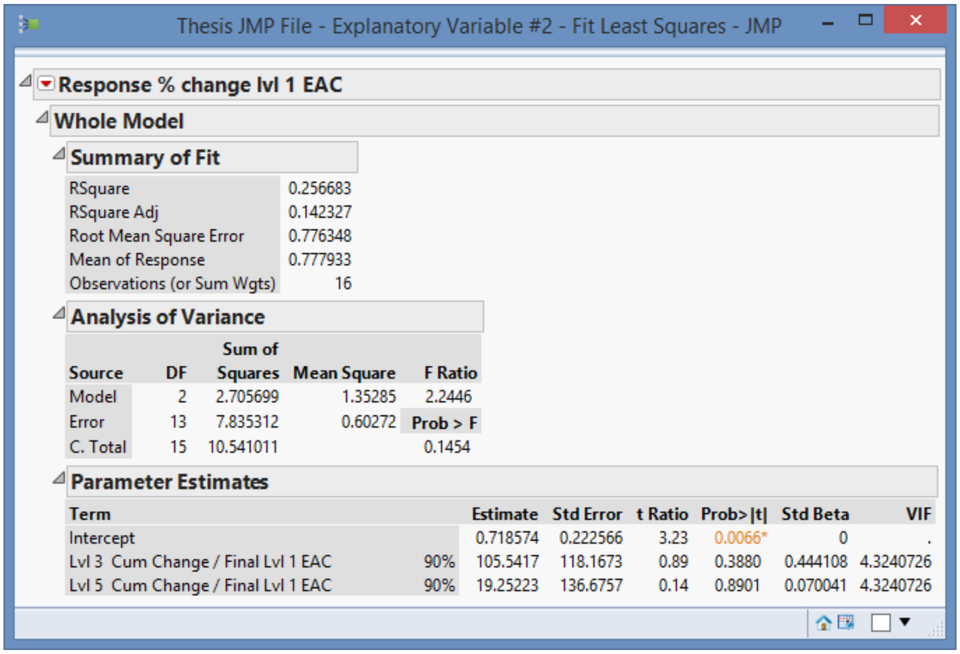
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.29153	0.29153	0.0440
Error	23	152.47927	6.62953	Prob > F
C. Total	24	152.77081		0.8357

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.1443494	0.556376	2.06	0.0512	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	85%	11.012138	52.51343	0.21	0.8357	0.043684	1



Growth Definition #2 Bin - 90%



Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

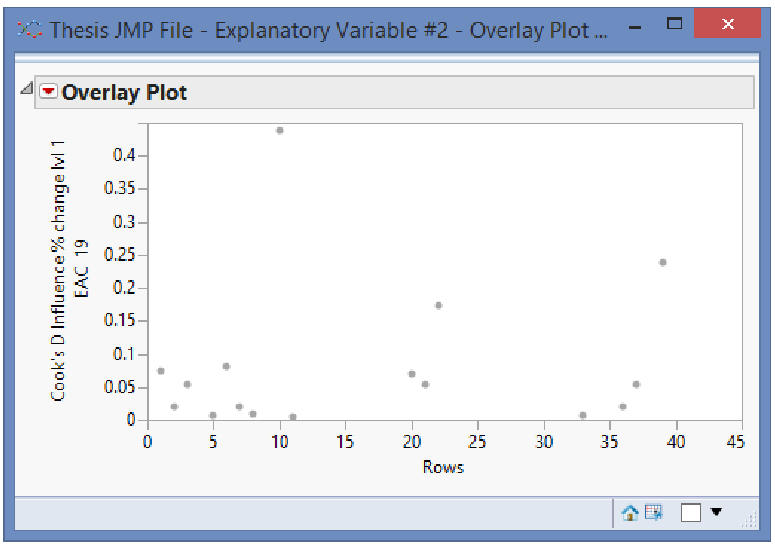
RSquare	0.256683
RSquare Adj	0.142327
Root Mean Square Error	0.776348
Mean of Response	0.777933
Observations (or Sum Wgts)	16

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	2.705699	1.35285	2.2446
Error	13	7.835312	0.60272	Prob > F
C. Total	15	10.541011		0.1454

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.718574	0.222566	3.23	0.0066*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	90%	105.5417	118.1673	0.89	0.3880	0.444108	4.3240726
Lvl 5 Cum Change / Final Lvl 1 EAC	90%	19.25223	136.6757	0.14	0.8901	0.070041	4.3240726



Growth Definition #2 Bin - 95%

Thesis JMP File - Explanatory Variable #2 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

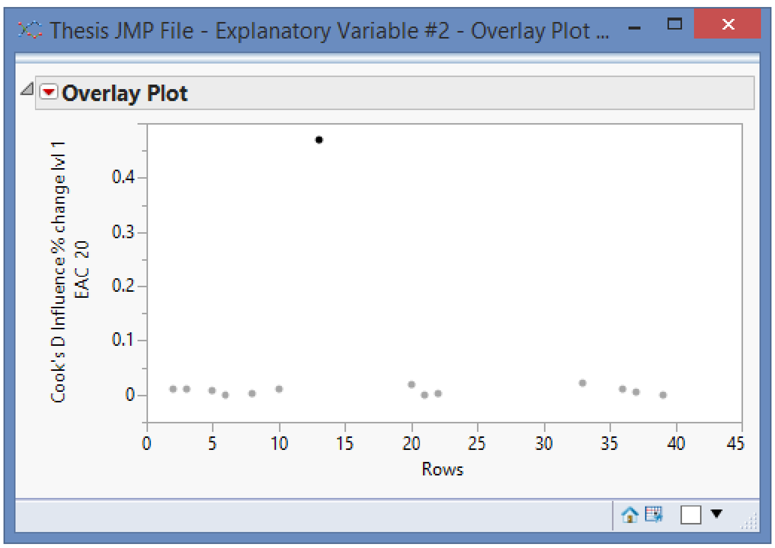
RSquare	0.001877
RSquare Adj	-0.0813
Root Mean Square Error	3.403195
Mean of Response	1.651156
Observations (or Sum Wgts)	14

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.26139	0.2614	0.0226
Error	12	138.98082	11.5817	Prob > F
C. Total	13	139.24221		0.8831

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.6011958	0.968432	1.65	0.1242	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	95%	12.034731	80.10797	0.15	0.8831	0.043327	1



Appendix F – JMP® Output Screens for Growth Definition #3

Growth Definition #3 Bin - 5%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.500839
RSquare Adj	0.084872
Root Mean Square Error	0.887337
Mean of Response	0.607487
Observations (or Sum Wgts)	34

Analysis of Variance

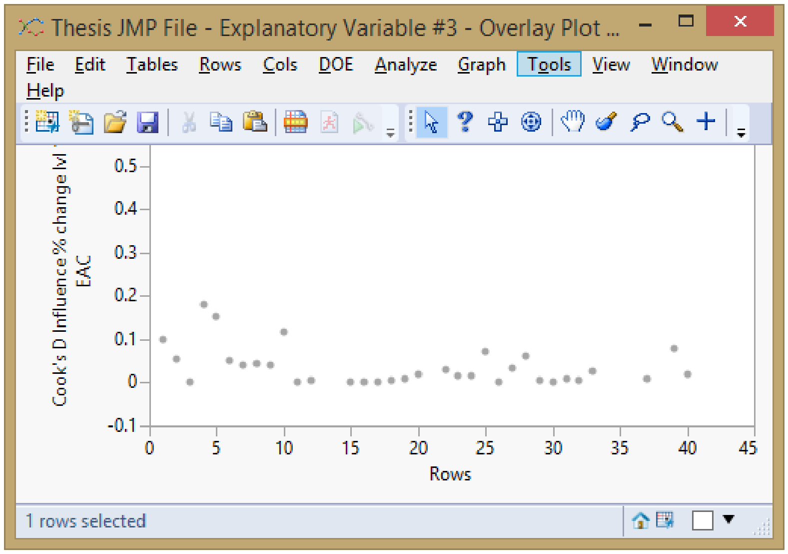
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	15	14.220252	0.948017	1.2040
Error	18	14.172596	0.787366	Prob > F
C. Total	33	28.392848		0.3498

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.3543905	0.695648	0.51	0.6166	0	.
# Lvl 3 Elements with EAC Data	-0.000044	0.019116	-0.00	0.9982	-0.0006	2.4516382
# Lvl 5 with EAC data elements <= 30	0.8351154	0.58104	1.44	0.1678	0.427526	3.1906335
RDT&E	-0.068881	0.420066	-0.16	0.8716	-0.03663	1.7994585
Air Force	0.902058	0.713495	1.26	0.2223	0.31804	2.2819553
Navy	-0.049727	0.487851	-0.10	0.9199	-0.02546	2.2492541
Aircraft	0.2845607	0.475243	0.60	0.5568	0.132088	1.7548484
Missile	0.2914338	0.589724	0.49	0.6272	0.112948	1.8836908
General Dynamics Corporation	0.5349049	0.705772	0.76	0.4583	0.166025	1.7304354
Lockheed Martin Corporation	0.4926465	0.836905	0.59	0.5634	0.126847	1.6744678
The Boeing Company	-0.87839	0.840381	-1.05	0.3098	-0.27264	2.4534615
Top 5 DOD Contractor	0.0398866	0.534491	0.07	0.9413	0.019888	2.5611525
12 - 24 Months	-1.084314	0.446805	-2.43	0.0260*	-0.58397	2.0880332
24 - 36	0.0235645	0.560123	0.04	0.9669	0.010938	2.4376646
% of Contract covered 25% - 50%	0.3591481	0.644293	0.56	0.5841	0.139192	2.2484295
% of Contract covered 50% - 75%	0.5809915	0.49691	1.17	0.2576	0.303828	2.4350294

Effect Tests

Effect Details



Growth Definition #3 Bin - 10%

Thesis JMP File - Explanatory Variable #3 - Fit Least Squares 2 - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

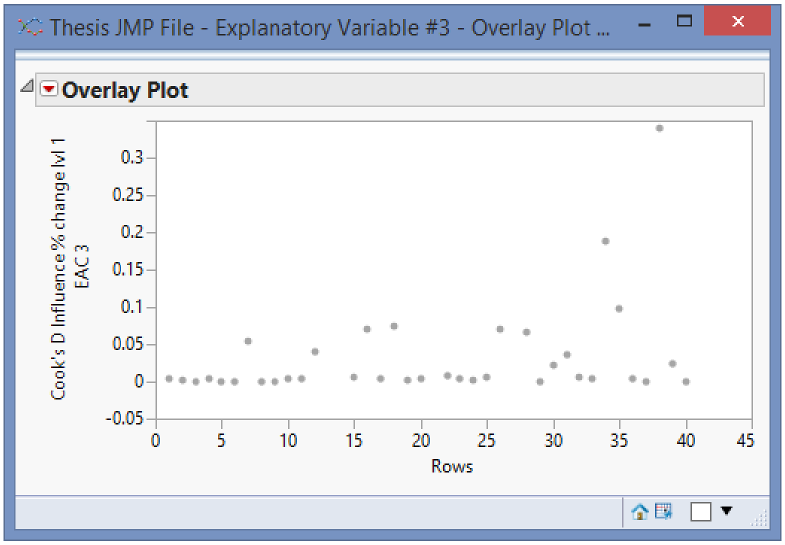
RSquare	0.225539
RSquare Adj	0.178602
Root Mean Square Error	1.19327
Mean of Response	0.820696
Observations (or Sum Wgts)	36

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	13.684036	6.84202	4.8051
Error	33	46.988487	1.42389	Prob > F
C. Total	35	60.672523		0.0147*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.5459517	0.276188	1.98	0.0565	0	.
ELECTRONIC/AUTOMATED SOFTWARE	-0.573362	0.459546	-1.25	0.2209	-0.19124	1.0011161
% of Contract covered 50% - 75%	1.1577739	0.414283	2.79	0.0086*	0.428363	1.0011161



Growth Definition #3 Bin - 15%

Thesis JMP File - Explanatory Variable #3 - Fit Least Squares 2 - J...

Response % change lvl 1 EAC

Whole Model

Summary of Fit

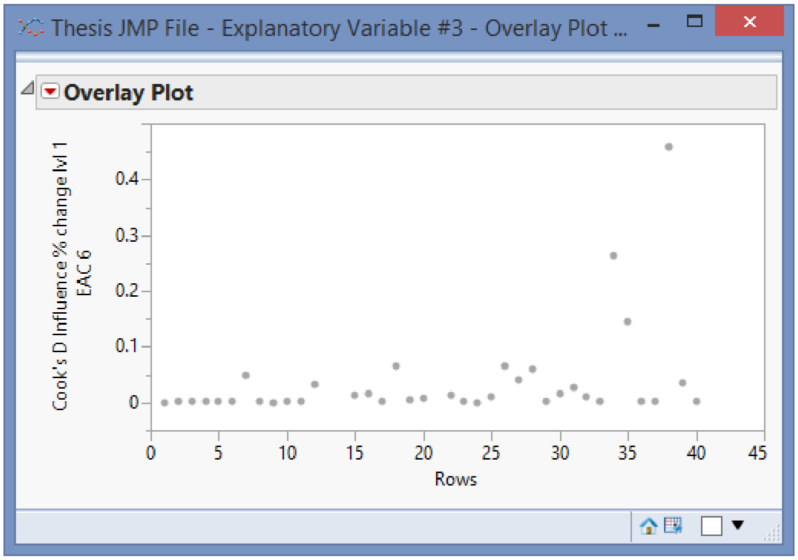
RSquare	0.167795
RSquare Adj	0.144018
Root Mean Square Error	1.203738
Mean of Response	0.806527
Observations (or Sum Wgts)	37

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	10.225442	10.2254	7.0570
Error	35	50.714514	1.4490	Prob > F
C. Total	36	60.939956		0.0118*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.396379	0.250997	1.58	0.1233	0	.
% of Contract covered 50% - 75%	1.0839618	0.408042	2.66	0.0118*	0.409628	1


Thesis JMP File - Explanatory Variable #3 - Overlay Plot ...
Overlay Plot
Cook's D Influence % change lvl 1 EAC 6
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
40
45
Rows

Growth Definition #3 Bin - 20%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.747205
RSquare Adj	0.397181
Root Mean Square Error	0.482291
Mean of Response	0.463572
Observations (or Sum Wgts)	32

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	18	8.937827	0.496546	2.1347
Error	13	3.023854	0.232604	Prob > F
C. Total	31	11.961682		0.0841

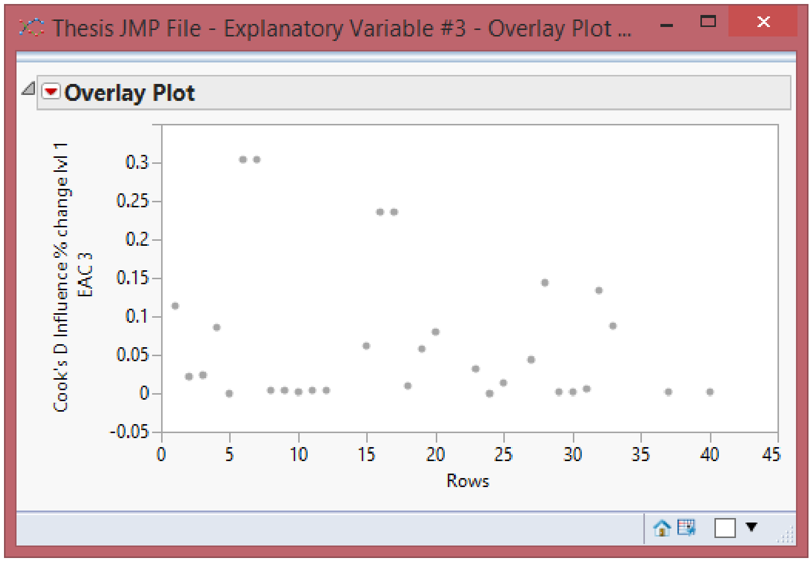
Lack Of Fit

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	1.4859253	0.438057	3.39	0.0048*	0	.
# Lvl 5 with EAC data elements > 30 and < 150	-0.509461	0.277445	-1.84	0.0893	-0.41337	2.6060836
RDT&E	0.2303898	0.247795	0.93	0.3694	0.182431	1.9798311
Air Force	0.8813121	0.444894	1.98	0.0692	0.476725	2.9782624
ELECTRONIC/AUTOMATED SOFTWARE	-0.225637	0.248786	-0.91	0.3809	-0.16593	1.7212942
Ordance	0.1279465	0.465472	0.27	0.7877	0.050656	1.7465091
Ship	-0.6629	0.417073	-1.59	0.1360	-0.35858	2.6174318
Space	1.2021825	0.724801	1.66	0.1211	0.342121	2.1879244
UAV	-0.297676	0.450099	-0.66	0.5199	-0.11786	1.6330539
Other 2	-0.483521	0.555154	-0.87	0.3996	-0.19143	2.4843411
CPFF	-0.72487	0.475237	-1.53	0.1511	-0.34558	2.639811
CPIF	-0.407821	0.264449	-1.54	0.1470	-0.30918	2.0669906
Lockheed Martin Corporation	0.2529987	0.458416	0.55	0.5904	0.100167	1.6939585
Telephonics Corporation	0.1534961	0.560733	0.27	0.7886	0.043682	1.3095026
The Boeing Company	-1.420065	0.537571	-2.64	0.0203*	-0.67701	3.3777153
12 - 24 Months	-0.970825	0.27158	-3.57	0.0034*	-0.78772	2.4970512
24 - 36	-0.698966	0.353891	-1.98	0.0699	-0.47261	2.9444852
% of Contract covered 25% - 50%	0.497168	0.357712	1.39	0.1879	0.295256	2.3207787
% of Contract covered > 75%	-0.279752	0.289052	-0.97	0.3508	-0.21732	2.592955

Effect Tests

Effect Details



Growth Definition #3 Bin - 25%

Thesis JMP File - Explanatory Variable #3 - Fit Least Squares 2 - J...

Response % change lvl 1 EAC

Whole Model

Summary of Fit

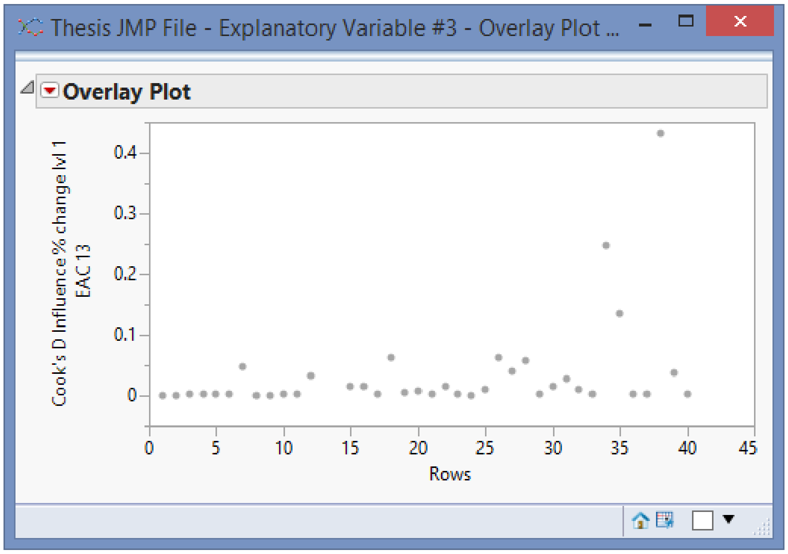
RSquare	0.178451
RSquare Adj	0.15563
Root Mean Square Error	1.187727
Mean of Response	0.831491
Observations (or Sum Wgts)	38

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	11.031171	11.0312	7.8197
Error	36	50.785003	1.4107	Prob > F
C. Total	37	61.816173		0.0082*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.396379	0.247658	1.60	0.1182	0	.
% of Contract covered 50% - 75%	1.1022828	0.394184	2.80	0.0082*	0.422435	1



Growth Definition #3 Bin – 30%

Thesis JMP File - Explanatory Variable #3 - Fit Least Squares 2 ...

Response % change lvl 1 EAC

Whole Model

Summary of Fit

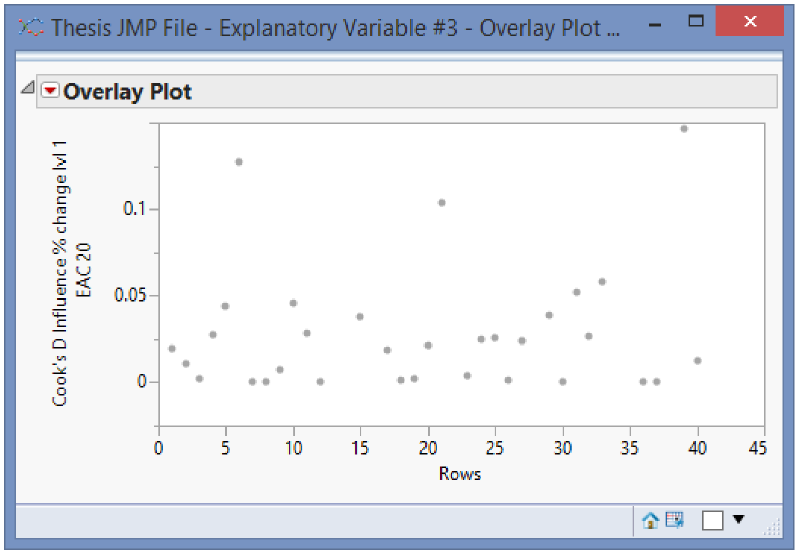
RSquare	0.515625
RSquare Adj	0.463728
Root Mean Square Error	0.425855
Mean of Response	0.4458
Observations (or Sum Wgts)	32

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	5.405490	1.80183	9.9355
Error	28	5.077875	0.18135	Prob > F
C. Total	31	10.483365		0.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	1.1476122	0.163679	7.01	<.0001*	0	.
Navy	-0.466747	0.165764	-2.82	0.0088*	-0.38731	1.09375
Washington Demil Company	-0.965266	0.456227	-2.12	0.0434*	-0.29343	1.1118608
12 - 24 Months	-0.779403	0.155058	-5.03	<.0001*	-0.67953	1.0564631



Growth Definition #3 Bin - 35%

Thesis JMP File - Explanatory Variable #3 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

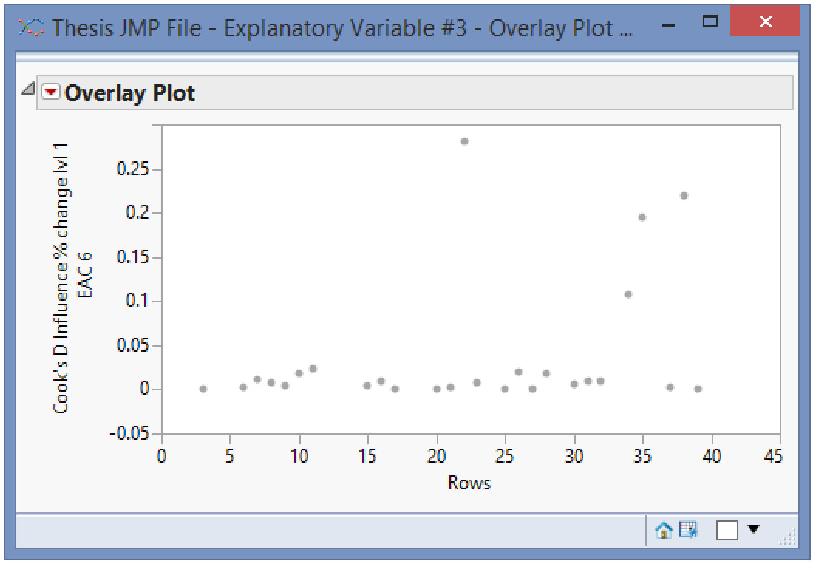
RSquare	0.308683
RSquare Adj	0.248569
Root Mean Square Error	1.243791
Mean of Response	1.180523
Observations (or Sum Wgts)	26

Analysis of Variance

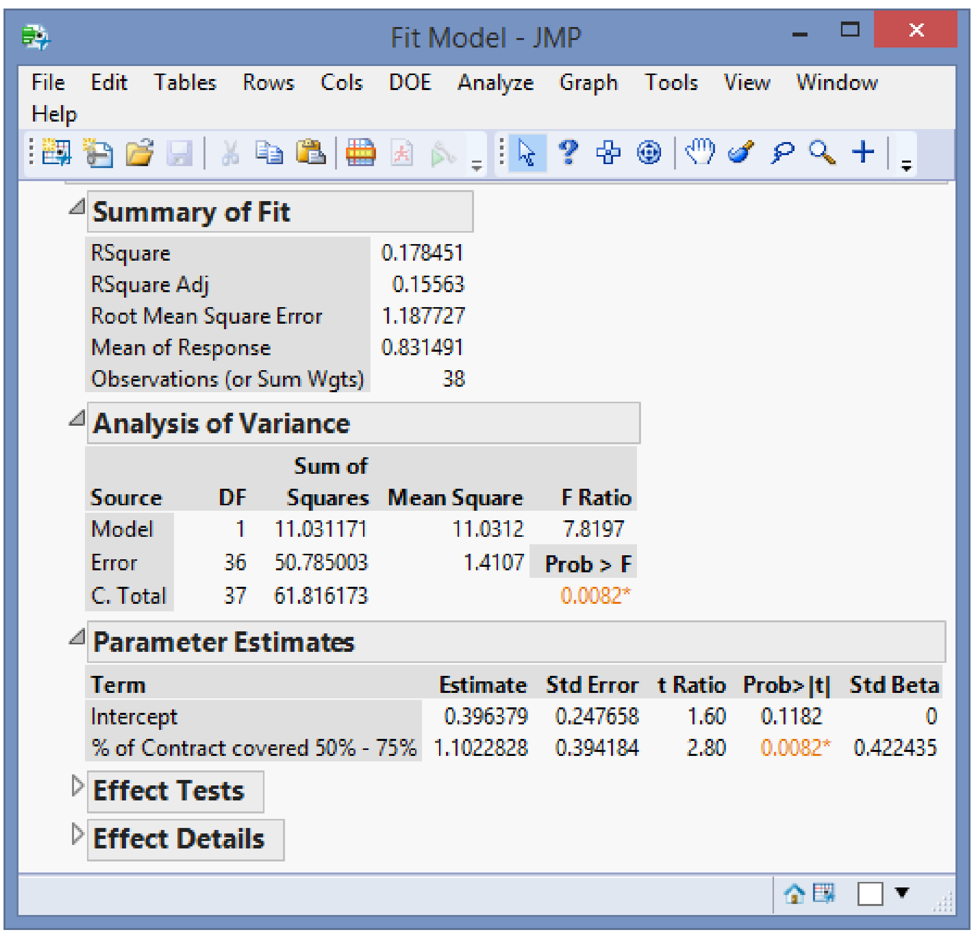
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	15.887604	7.94380	5.1349
Error	23	35.581378	1.54702	Prob > F
C. Total	25	51.468982		0.0143*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		1.2467516	0.287181	4.34	0.0002*	0	.
FPIF		-1.091335	0.578953	-1.89	0.0721	-0.32681	1.0000001
Lvl 3 Cum Change / Final Lvl 1 EAC	35%	1.0103857	0.389785	2.59	0.0163*	0.449403	1.0000001



Growth Definition #3 Bin - 40%



Summary of Fit

RSquare	0.178451
RSquare Adj	0.15563
Root Mean Square Error	1.187727
Mean of Response	0.831491
Observations (or Sum Wgts)	38

Analysis of Variance

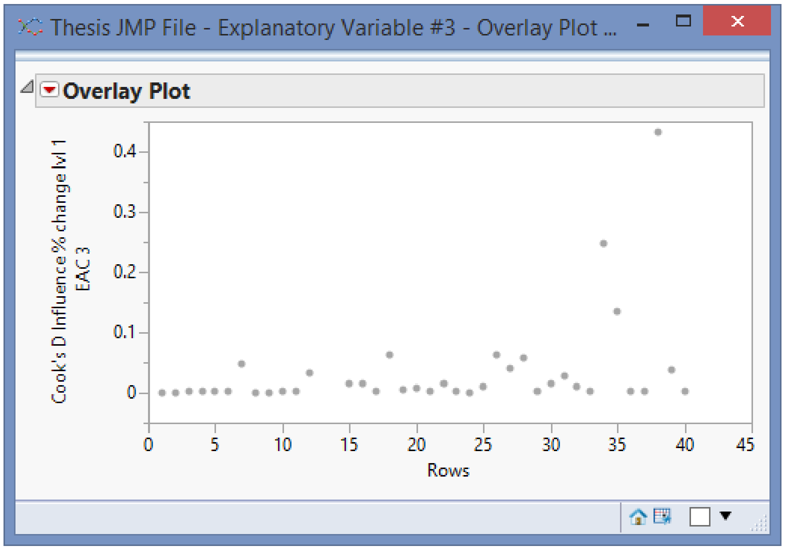
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	11.031171	11.0312	7.8197
Error	36	50.785003	1.4107	Prob > F
C. Total	37	61.816173		0.0082*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta
Intercept	0.396379	0.247658	1.60	0.1182	0
% of Contract covered 50% - 75%	1.1022828	0.394184	2.80	0.0082*	0.422435

Effect Tests

Effect Details



Growth Definition #3 Bin - 45%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.993052
RSquare Adj	0.988421
Root Mean Square Error	0.094069
Mean of Response	0.86612
Observations (or Sum Wgts)	11

Analysis of Variance

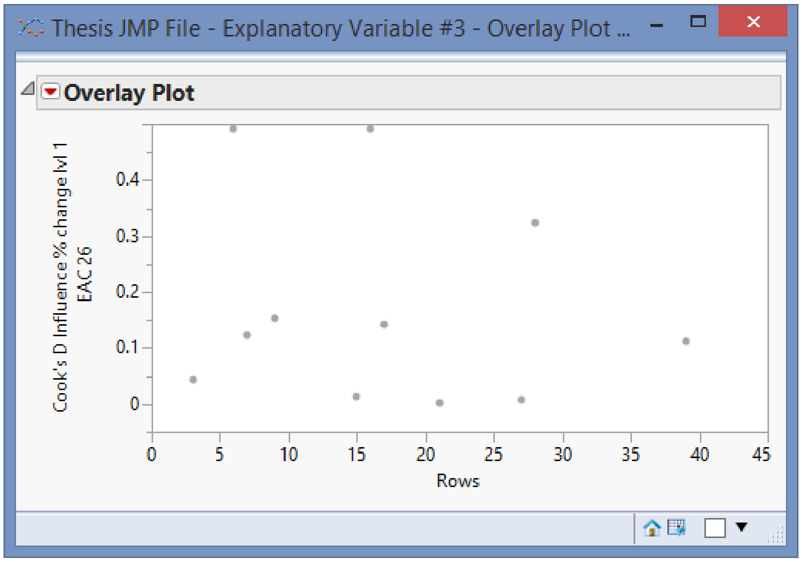
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	7.5890570	1.89726	214.4039
Error	6	0.0530941	0.00885	Prob > F
C. Total	10	7.6421511		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	-0.203701	0.062453	-3.26	0.0172*	0	.
CPAF	1.098726	0.082853	13.26	<.0001*	0.508419	1.2694015
Greater than 36	0.520096	0.06346	8.20	0.0002*	0.300164	1.158443
% of Contract covered 50% - 75%	-0.204551	0.06391	-3.20	0.0186*	-0.11805	1.1749083
Lvl 3 Cum Change / Final Lvl 1 EAC 45%	4.1069115	0.205551	19.98	<.0001*	0.691675	1.0349828

Effect Tests

Effect Details



Growth Definition #3 Bin - 50%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.991076
RSquare Adj	0.982151
Root Mean Square Error	0.049064
Mean of Response	0.368184
Observations (or Sum Wgts)	9

Analysis of Variance

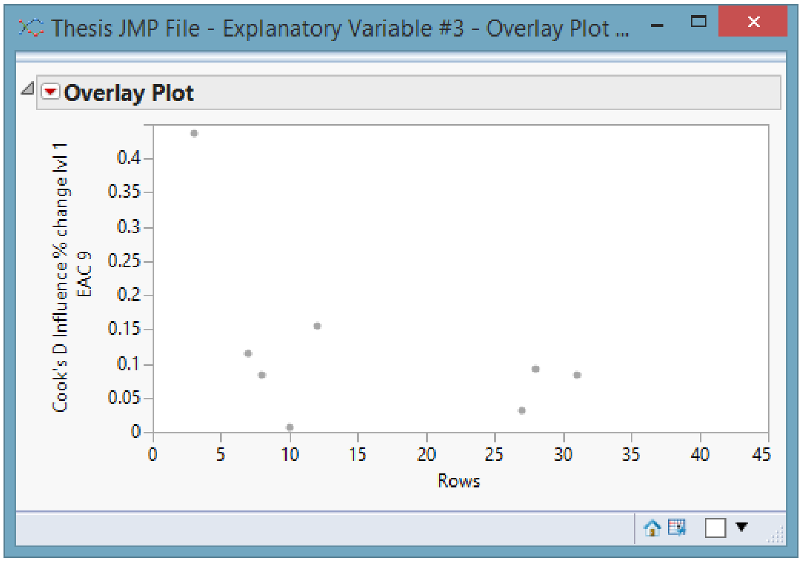
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	1.0693217	0.267330	111.0518
Error	4	0.0096290	0.002407	Prob > F
C. Total	8	1.0789507		0.0002*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.019485	0.031365	-0.62	0.5681	0	.
Army		0.2448289	0.04418	5.54	0.0052*	0.293971	1.2612773
CPIF		0.0902074	0.036304	2.48	0.0679	0.122816	1.0949862
Harris Corporation		0.5261825	0.062453	8.43	0.0011*	0.477595	1.4402397
Lvl 3 Cum Change / Final Lvl 1 EAC	50%	1.8111293	0.145488	12.45	0.0002*	0.763015	1.6838318

Effect Tests

Effect Details



Growth Definition #3 Bin - 55%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.996923
RSquare Adj	0.993406
Root Mean Square Error	0.057874
Mean of Response	0.753243
Observations (or Sum Wgts)	16

Analysis of Variance

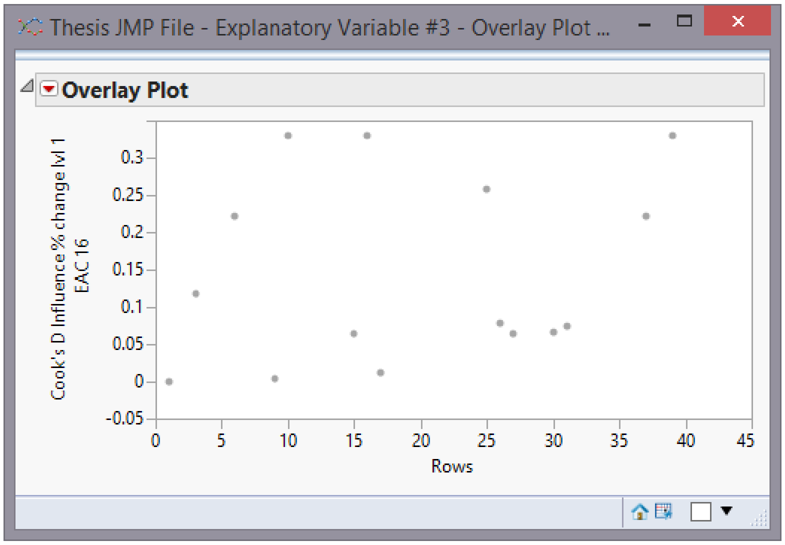
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	7.5962567	0.949532	283.4947
Error	7	0.0234457	0.003349	Prob > F
C. Total	15	7.6197024		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.309122	0.068111	-4.54	0.0027*	0	.
# Lvl 5 with EAC data elements > = 150		0.4501135	0.057376	7.84	0.0001*	0.302325	3.3786207
Air Force		1.0977052	0.060175	18.24	<.0001*	0.526061	1.8919558
Raytheon Company		0.1663711	0.071256	2.33	0.0522	0.058357	1.4211752
The Boeing Company		-0.404951	0.055708	-7.27	0.0002*	-0.19407	1.6214933
12 - 24 Months		0.2449866	0.072737	3.37	0.0120*	0.164549	5.429879
Greater than 36		0.6935551	0.053188	13.04	<.0001*	0.502507	3.3784945
% of Contract covered 50% - 75%		0.1591668	0.038451	4.14	0.0044*	0.114418	1.7380952
Lvl 3 Cum Change / Final Lvl 1 EAC	55%	1.5566072	0.097711	15.93	<.0001*	0.44685	1.78989

Effect Tests

Effect Details



Growth Definition #3 Bin - 60%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.906008
RSquare Adj	0.843347
Root Mean Square Error	0.273841
Mean of Response	0.502396
Observations (or Sum Wgts)	16

Analysis of Variance

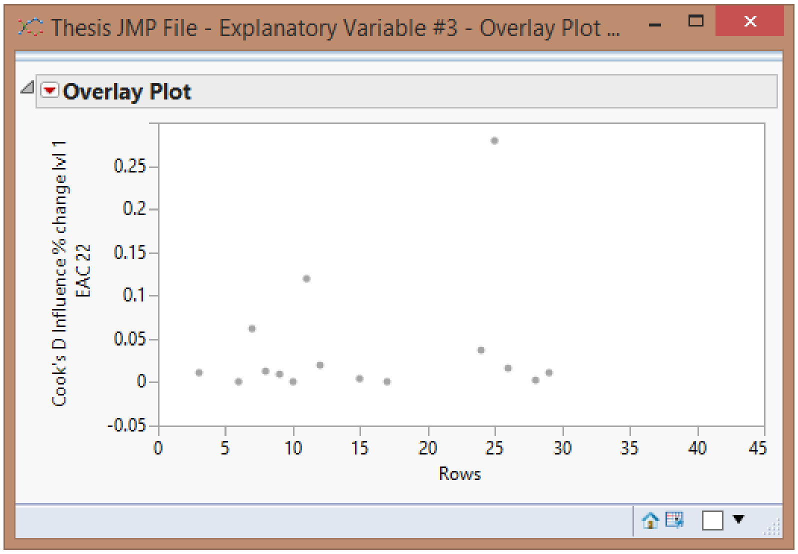
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	6.5055143	1.08425	14.4589
Error	9	0.6748991	0.07499	Prob > F
C. Total	15	7.1804134		0.0004*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.2030221	0.120872	1.68	0.1273	0	.
Total # Lvl 3 Elements	-0.003159	0.0042	-0.75	0.4712	-0.08194	1.1364166
Missile	-1.916312	0.417328	-4.59	0.0013*	-0.69243	2.1773584
Ship	0.3176228	0.185375	1.71	0.1208	0.185059	1.1169902
EG&G	1.221276	0.304057	4.02	0.0030*	0.441291	1.1558079
Lockheed Martin Corporation	1.7343258	0.309927	5.60	0.0003*	0.8562	2.2416188
Lvl 5 Cum Change / Final Lvl 1 EAC 60%	0.7810687	0.22803	3.43	0.0076*	0.396576	1.2835474

Effect Tests

Effect Details



Growth Definition #3 Bin - 65%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.993305
RSquare Adj	0.984379
Root Mean Square Error	0.157231
Mean of Response	0.843488
Observations (or Sum Wgts)	22

Analysis of Variance

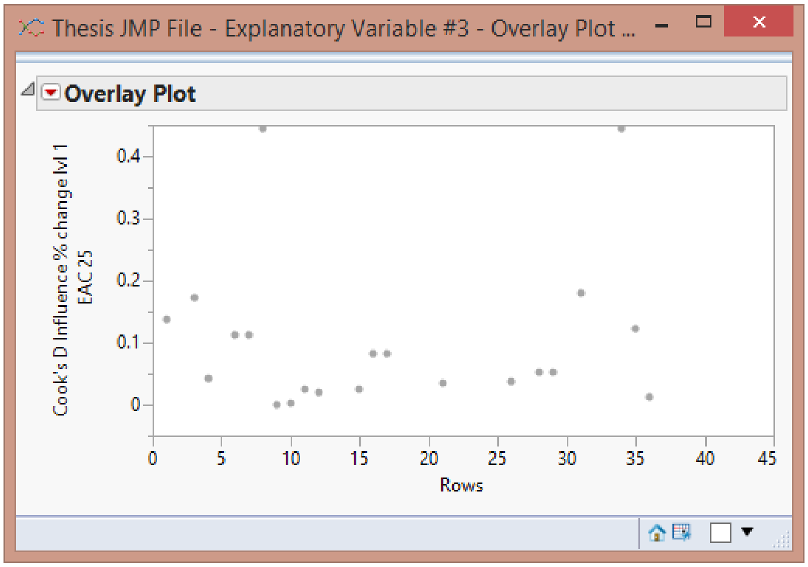
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	12	33.010959	2.75091	111.2762
Error	9	0.222493	0.02472	Prob > F
C. Total	21	33.233453		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.3630338	0.105477	3.44	0.0074*	0	.
# Lvl 5 with EAC data elements > 30 and < 150		-0.388665	0.127704	-3.04	0.0139*	-0.14084	2.8786318
# Lvl 5 with EAC data elements > = 150		-1.270957	0.145218	-8.75	<.0001*	-0.43335	3.2958283
Prod		0.5874598	0.106984	5.49	0.0004*	0.222625	2.209669
Army		-1.026624	0.113984	-9.01	<.0001*	-0.38905	2.508289
Other 2		1.3660033	0.238019	5.74	0.0003*	0.319509	4.1666377
CPAF		-0.413122	0.11591	-3.56	0.0061*	-0.15656	2.593772
CPFF		-0.936785	0.118478	-7.91	<.0001*	-0.26156	1.4711468
Harris Corporation		-0.508516	0.205813	-2.47	0.0355*	-0.08618	1.6355665
Lockheed Martin Corporation		0.8365008	0.165879	5.04	0.0007*	0.195658	2.0237081
Northrop Grumman Corporation		-0.662312	0.095346	-6.95	<.0001*	-0.22583	1.4207923
24 - 36		1.8089585	0.133042	13.60	<.0001*	0.505088	1.8550602
Lvl 3 Cum Change / Final Lvl 1 EAC	65%	3.7900738	0.153593	24.68	<.0001*	0.77563	1.3281796

Effect Tests

Effect Details


Thesis JMP File - Explanatory Variable #3 - Overlay Plot ...
Overlay Plot
Cook's D Influence % change lvl 1 EAC 25
0.4
0.3
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35
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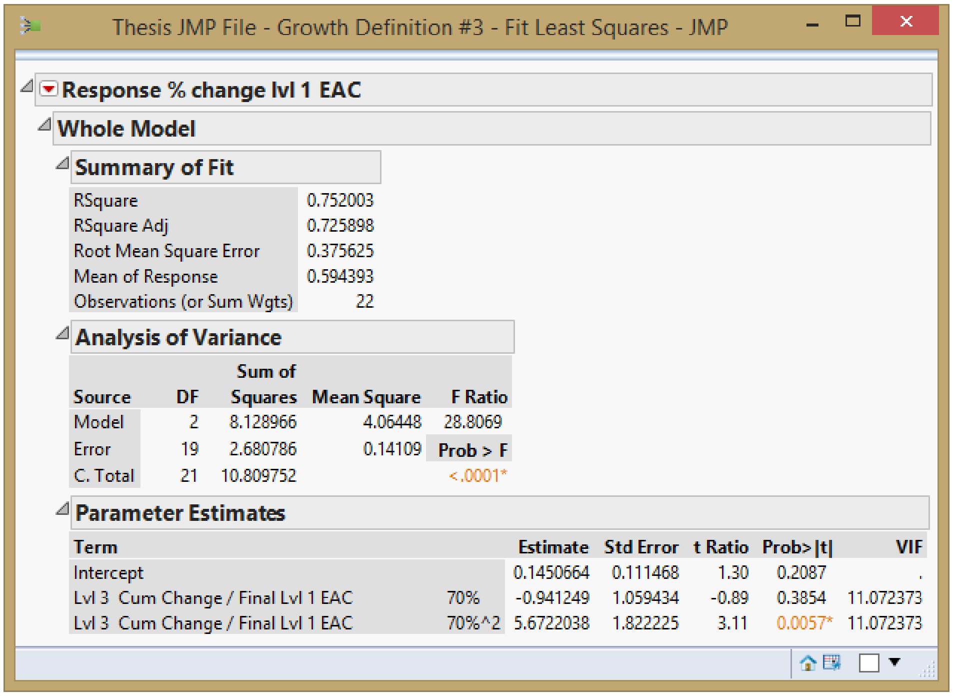
45
Rows

Growth Definition #3 Bin - 70%



Thesis JMP File - Growth Definition #3 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

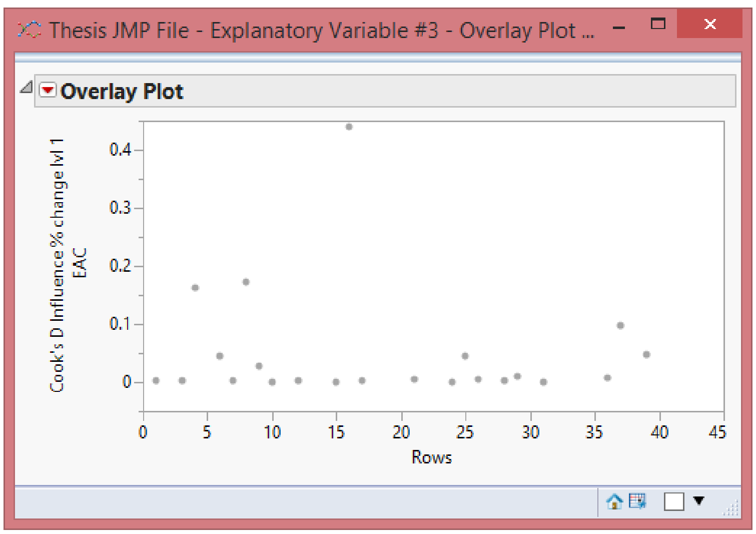
RSquare	0.752003
RSquare Adj	0.725898
Root Mean Square Error	0.375625
Mean of Response	0.594393
Observations (or Sum Wgts)	22

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	8.128966	4.06448	28.8069
Error	19	2.680786	0.14109	Prob > F
C. Total	21	10.809752		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept		0.1450664	0.111468	1.30	0.2087	.
Lvl 3 Cum Change / Final Lvl 1 EAC	70%	-0.941249	1.059434	-0.89	0.3854	11.072373
Lvl 3 Cum Change / Final Lvl 1 EAC	70%^2	5.6722038	1.822225	3.11	0.0057*	11.072373



Growth Definition #3 Bin - 75%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.994692
RSquare Adj	0.988853
Root Mean Square Error	0.078577
Mean of Response	0.558531
Observations (or Sum Wgts)	22

Analysis of Variance

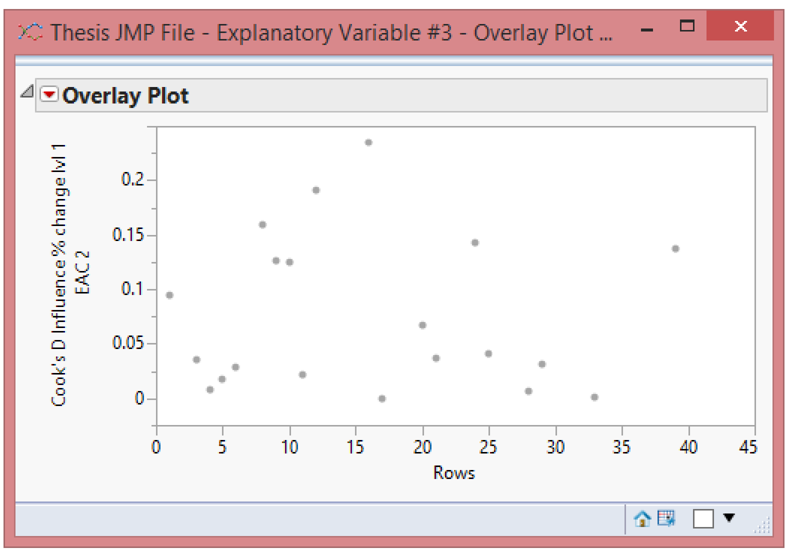
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	11.570418	1.05186	170.3571
Error	10	0.061744	0.00617	Prob > F
C. Total	21	11.632162		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.5277426	0.042444	12.43	<.0001*	0	.
# Lvl 5 Elements with EAC Data		-0.000432	3.576e-5	-12.09	<.0001*	-0.37236	1.7862204
Air Force		0.3258385	0.053681	6.07	0.0001*	0.172833	1.5274123
Aircraft		-0.714829	0.05231	-13.67	<.0001*	-0.41197	1.7122891
CPAF		0.3489384	0.060169	5.80	0.0002*	0.230843	2.9850144
CPFF		-0.315532	0.056965	-5.54	0.0002*	-0.16737	1.7200217
Bell-Boeing V-22 Program Office		0.9846679	0.111699	8.82	<.0001*	0.282071	1.9288561
Washington Demil Company		0.3427766	0.104925	3.27	0.0085*	0.098193	1.7019826
12 - 24 Months		-0.520783	0.046677	-11.16	<.0001*	-0.33359	1.6841124
% of Contract covered < 25%		-0.843762	0.083198	-10.14	<.0001*	-0.39821	2.9045997
% of Contract covered > 75%		-0.114173	0.041816	-2.73	0.0212*	-0.07818	1.5447215
Lvl 3 Cum Change / Final Lvl 1 EAC	75%	1.8810476	0.096408	19.51	<.0001*	0.668933	2.2143887

Effect Tests

Effect Details



Growth Definition #3 Bin - 80%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.968438
RSquare Adj	0.950402
Root Mean Square Error	0.162113
Mean of Response	0.546781
Observations (or Sum Wgts)	23

Analysis of Variance

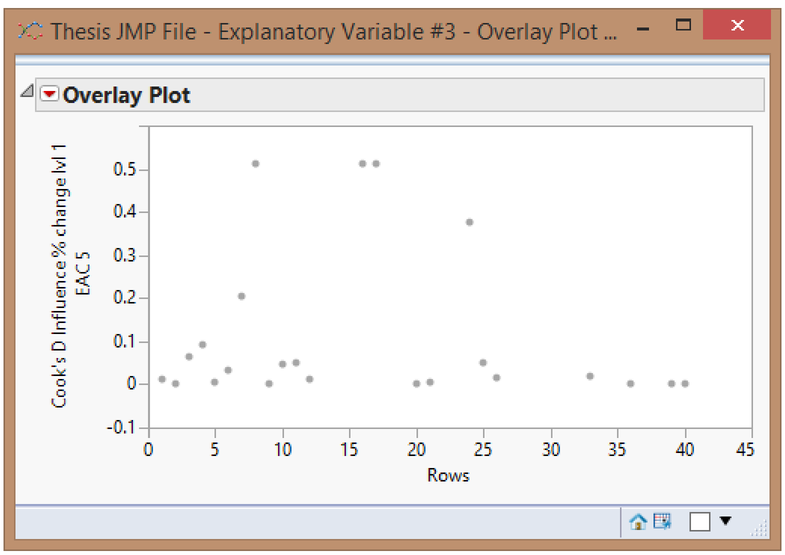
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	11.289428	1.41118	53.6963
Error	14	0.367930	0.02628	Prob > F
C. Total	22	11.657358		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.1301486	0.059521	2.19	0.0462*	0	.
Total # Lvl 5 Elements	0.0001998	0.000101	1.98	0.0678	0.270674	8.2956451
# Lvl 5 Elements with EAC Data	-0.00055	0.000161	-3.42	0.0041*	-0.47434	8.5097792
Aircraft	-0.219532	0.089171	-2.46	0.0274*	-0.12719	1.1839221
Space	0.4448915	0.187242	2.38	0.0323*	0.127439	1.2760448
Lockheed Martin Corporation	0.3613515	0.12654	2.86	0.0127*	0.143018	1.1126053
Greater than 36	0.6293136	0.093641	6.72	<.0001*	0.438202	1.8858634
% of Contract covered > 75%	-0.435959	0.075896	-5.74	<.0001*	-0.30357	1.2388503
Lvl 3 Cum Change / Final Lvl 1 EAC 80%	1.6968079	0.177114	9.58	<.0001*	0.646063	2.0172218

Effect Tests

Effect Details



Growth Definition #3 Bin - 85%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.257657
RSquare Adj	0.147681
Root Mean Square Error	1.270746
Mean of Response	0.851845
Observations (or Sum Wgts)	32

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	15.132811	3.78320	2.3428
Error	27	43.599471	1.61480	Prob > F
C. Total	31	58.732282		0.0802

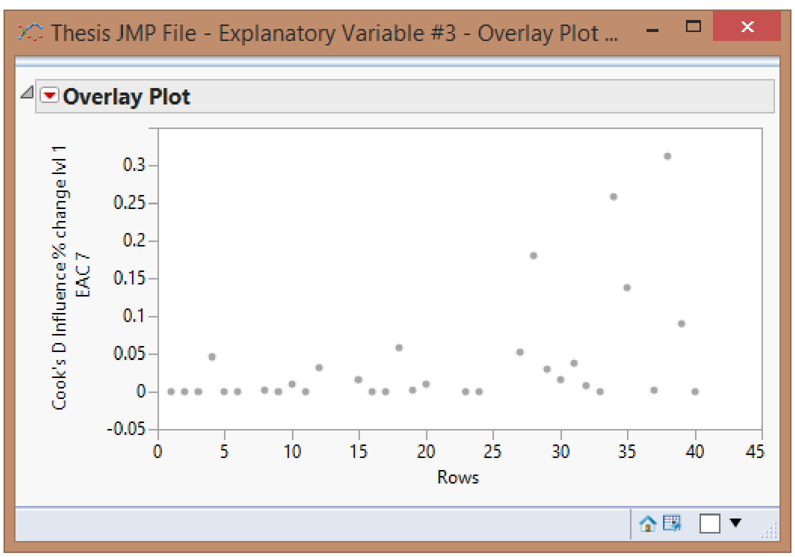
Lack Of Fit

Parameter Estimates

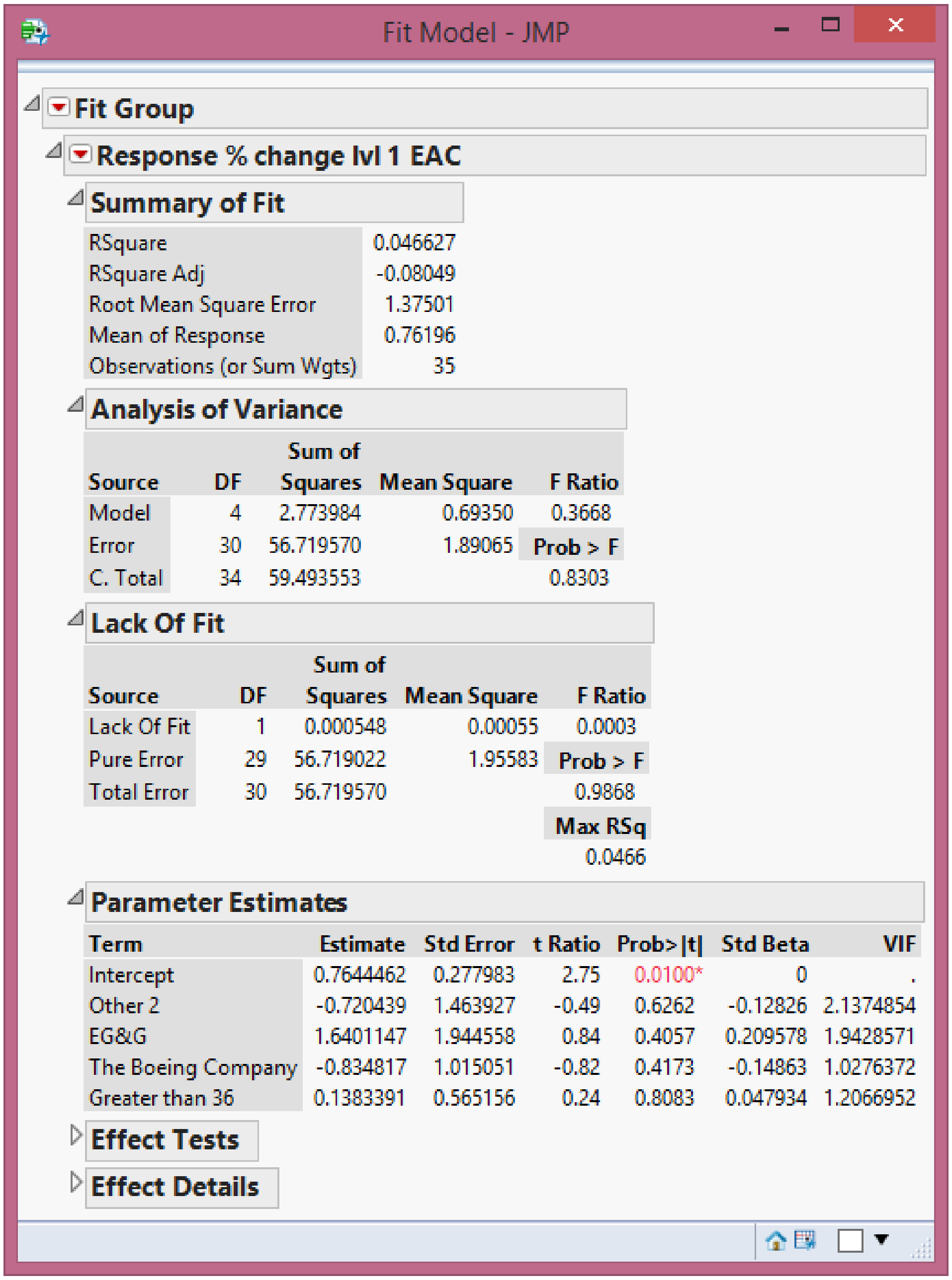
Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.219285	0.334056	0.66	0.5171	0	.
Air Force	0.3396782	0.69533	0.49	0.6291	0.082921	1.0479317
Aircraft	-0.050403	0.586621	-0.09	0.9322	-0.01538	1.1654308
Greater than 36	0.2323983	0.508697	0.46	0.6514	0.077127	1.0366246
% of Contract covered 50% - 75%	1.4287034	0.503459	2.84	0.0085*	0.510545	1.1772612

Effect Tests

Effect Details



Growth Definition #3 Bin - 90%



Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.046627
RSquare Adj	-0.08049
Root Mean Square Error	1.37501
Mean of Response	0.76196
Observations (or Sum Wgts)	35

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	2.773984	0.69350	0.3668
Error	30	56.719570	1.89065	Prob > F
C. Total	34	59.493553		0.8303

Lack Of Fit

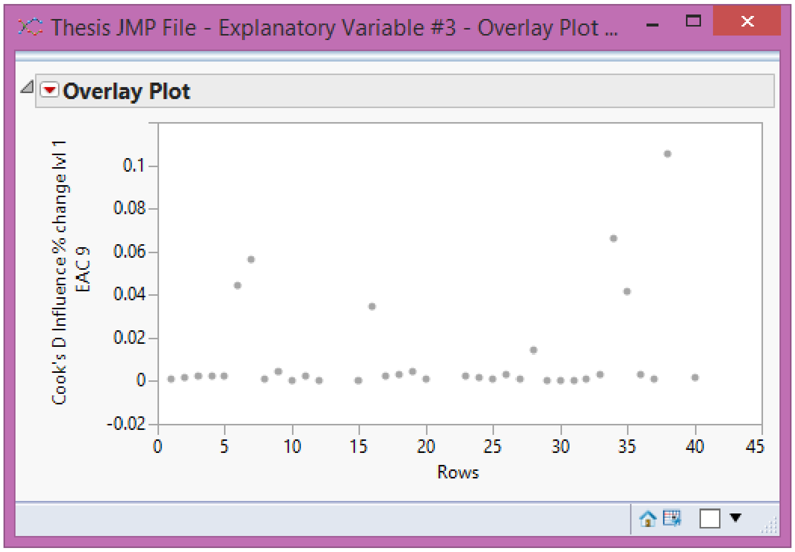
Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	1	0.000548	0.00055	0.0003
Pure Error	29	56.719022	1.95583	Prob > F
Total Error	30	56.719570		0.9868
				Max RSq
				0.0466

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.7644462	0.277983	2.75	0.0100*	0	.
Other 2	-0.720439	1.463927	-0.49	0.6262	-0.12826	2.1374854
EG&G	1.6401147	1.944558	0.84	0.4057	0.209578	1.9428571
The Boeing Company	-0.834817	1.015051	-0.82	0.4173	-0.14863	1.0276372
Greater than 36	0.1383391	0.565156	0.24	0.8083	0.047934	1.2066952

Effect Tests

Effect Details



Thesis JMP File - Explanatory Variable #3 - Overlay Plot ...
Overlay Plot
Cook's D Influence % change lvl 1 EAC 9
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0.08
0.06
0.04
0.02
0
-0.02
0
5
10
15
20
25
30
35
40
45
Rows

Growth Definition #3 Bin - 95%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.145953
RSquare Adj	-0.0602
Root Mean Square Error	1.346754
Mean of Response	0.81874
Observations (or Sum Wgts)	37

Analysis of Variance

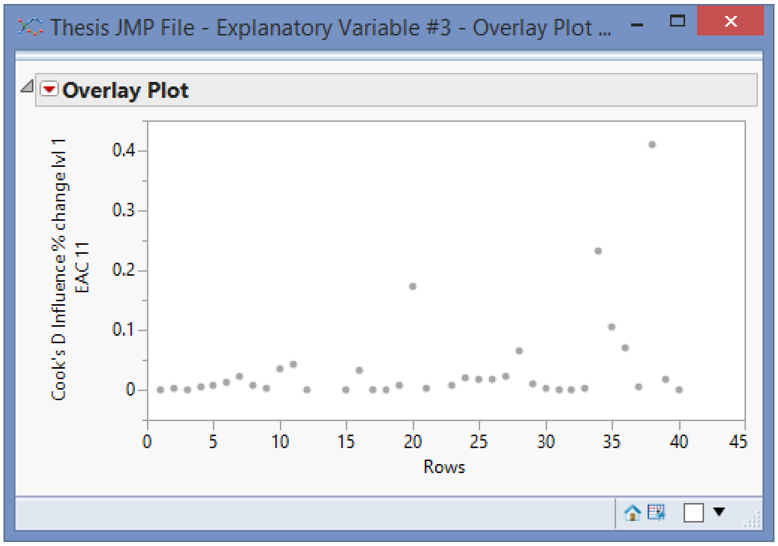
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	8.988916	1.28413	0.7080
Error	29	52.598663	1.81375	Prob > F
C. Total	36	61.587579		0.6654

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	-0.115251	0.620535	-0.19	0.8540	0	.
Total # Lvl 3 Elements	0.0213055	0.013372	1.59	0.1219	0.337286	1.5216863
Prod	0.8209731	0.529969	1.55	0.1322	0.30378	1.305801
Navy	-0.037243	0.500848	-0.07	0.9412	-0.01351	1.1213853
Aircraft	0.4053572	0.54172	0.75	0.4603	0.139532	1.1806871
CPFF	-0.188159	0.779173	-0.24	0.8109	-0.04529	1.1941628
CPIF	0.4347107	0.528186	0.82	0.4172	0.15773	1.2471456
Greater than 36	0.0461569	0.529181	0.09	0.9311	0.016747	1.2518482

Effect Tests

Effect Details



Growth Definition #3 Bin - 100%

Thesis JMP File - Explanatory Variable #3 - Fit Least Squares - J...

Response % change lvl 1 EAC

Whole Model

Summary of Fit

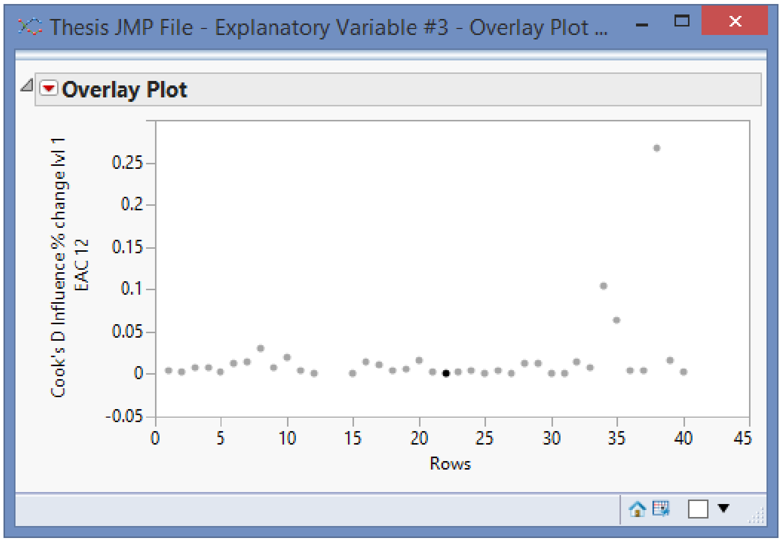
RSquare	0.034283
RSquare Adj	-0.11661
Root Mean Square Error	1.365844
Mean of Response	0.831491
Observations (or Sum Wgts)	38

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	2.119259	0.42385	0.2272
Error	32	59.696914	1.86553	Prob > F
C. Total	37	61.816173		0.9480

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.6714592	0.370852	1.81	0.0796	0	.
# Lvl 3 Elements with EAC Data	0.008747	0.017303	0.51	0.6166	0.113409	1.6676063
# Lvl 5 Elements with EAC Data	-0.000186	0.000541	-0.34	0.7333	-0.07201	1.4549512
Missile	-0.309341	0.672507	-0.46	0.6486	-0.08199	1.0526687
Top 3 DOD Contractor	0.1183296	0.492148	0.24	0.8115	0.045348	1.1787607
Greater than 36	0.175749	0.527354	0.33	0.7411	0.065372	1.2749774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Overlay Plot
Cook's D Influence % change lvl 1 EAC 12
0.25
0.2
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0.1
0.05
0
-0.05
0
5
10
15
20
25
30
35
40
45
Rows

Appendix G – JMP® Output Screens for Growth Definition #4

Growth Definition #4 Bin - 5%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.147679
RSquare Adj	0.096023
Root Mean Square Error	1.01794
Mean of Response	0.742221
Observations (or Sum Wgts)	36

Analysis of Variance

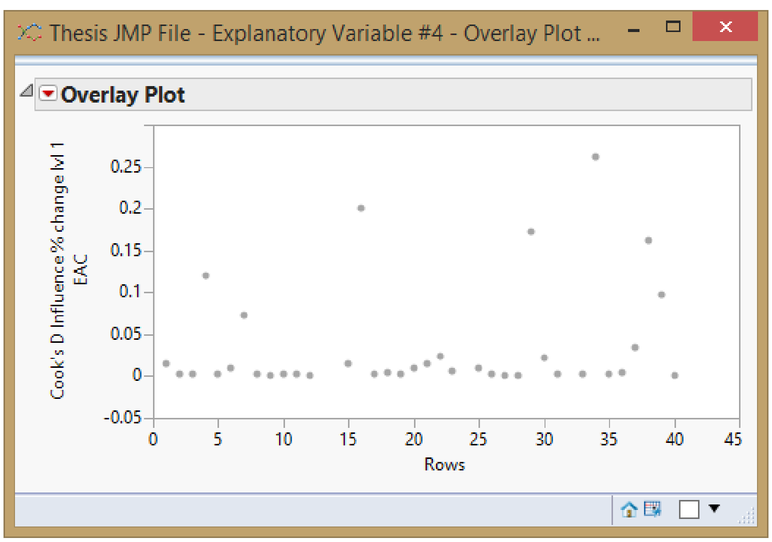
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	5.924820	2.96241	2.8589
Error	33	34.194688	1.03620	Prob > F
C. Total	35	40.119508		0.0716

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.4440239	0.212255	2.09	0.0442*	0	.
# Lvl 5 with EAC data elements > = 150	0.9202757	0.400232	2.30	0.0280*	0.377478	1.0434783
Air Force	0.6131533	0.551455	1.11	0.2742	0.182535	1.0434783

Effect Tests

Effect Details



Growth Definition #4 Bin - 10%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.189784
RSquare Adj	0.165954
Root Mean Square Error	0.977775
Mean of Response	0.742221
Observations (or Sum Wgts)	36

Analysis of Variance

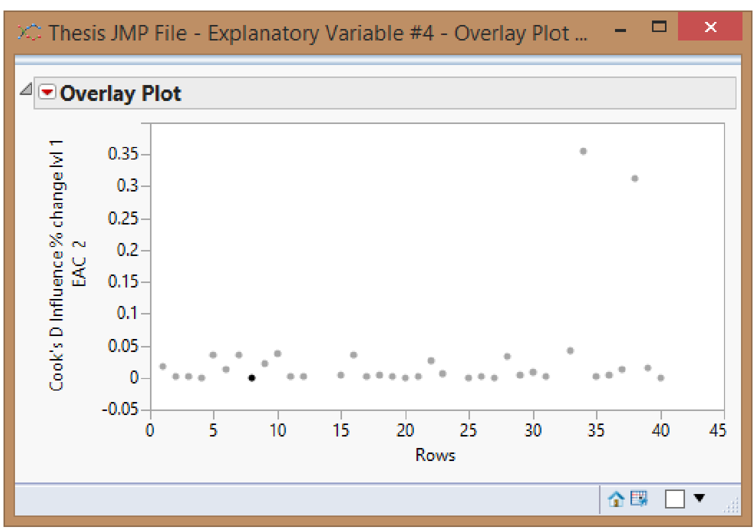
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	7.614033	7.61403	7.9641
Error	34	32.505476	0.95604	Prob > F
C. Total	35	40.119508		0.0079*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	1.1772355	0.224317	5.25	<.0001*	0	.
12 - 24 Months	-0.921207	0.326429	-2.82	0.0079*	-0.43564	1

Effect Tests

Effect Details



Growth Definition #4 Bin - 15%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.251717
RSquare Adj	0.206366
Root Mean Square Error	0.953793
Mean of Response	0.742221
Observations (or Sum Wgts)	36

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	10.098743	5.04937	5.5505
Error	33	30.020765	0.90972	Prob > F
C. Total	35	40.119508		0.0084*

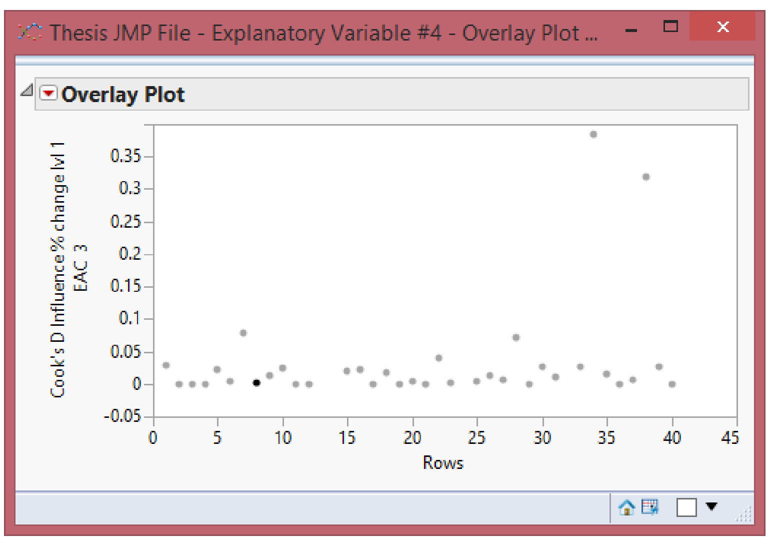
Lack Of Fit

Parameter Estimates

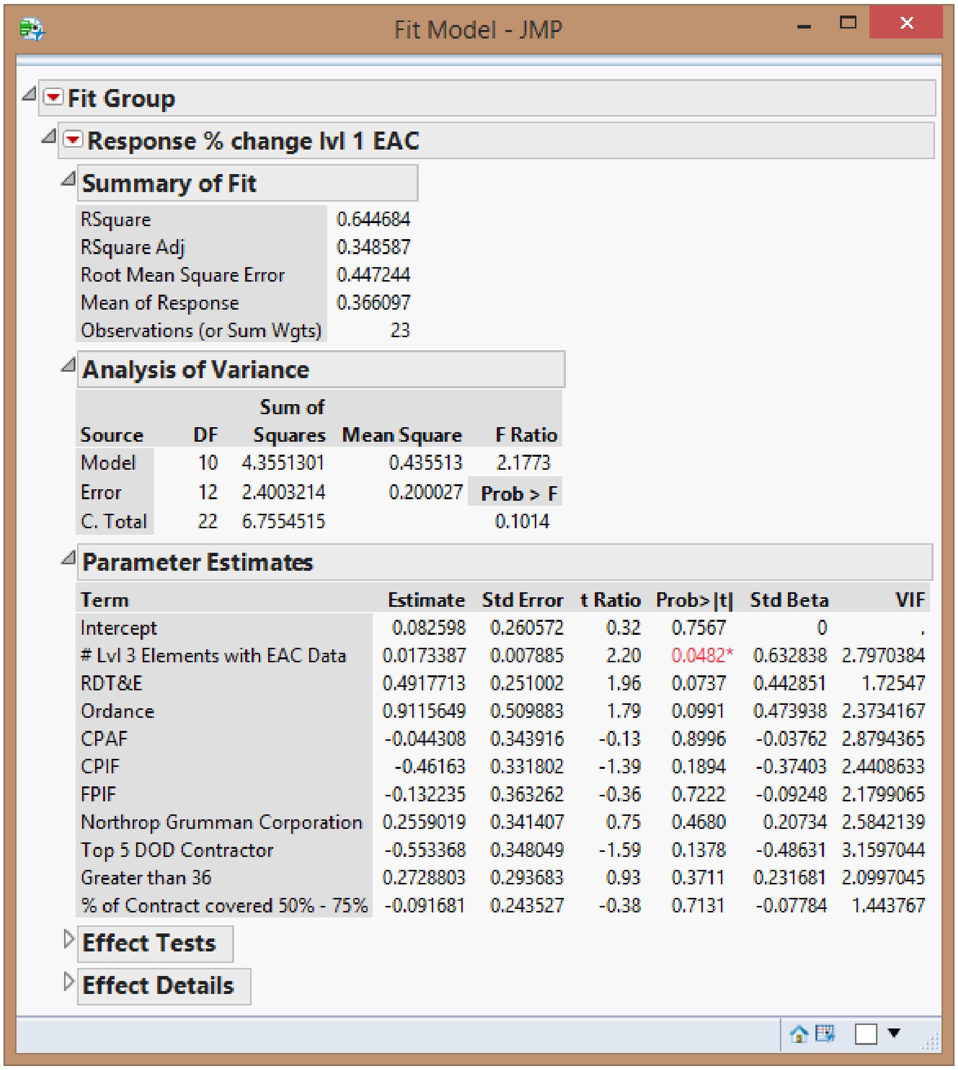
Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.9528528	0.257514	3.70	0.0008*	0	.
12 - 24 Months	-0.916258	0.318437	-2.88	0.0070*	-0.4333	1.0000885
% of Contract covered 50% - 75%	0.5329091	0.322455	1.65	0.1079	0.248874	1.0000885

Effect Tests

Effect Details



Growth Definition #4 Bin - 20%



Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.644684
RSquare Adj	0.348587
Root Mean Square Error	0.447244
Mean of Response	0.366097
Observations (or Sum Wgts)	23

Analysis of Variance

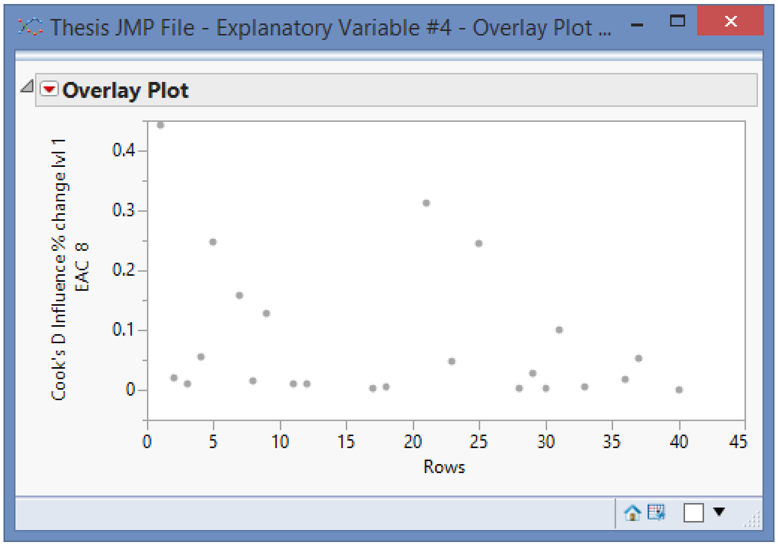
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	10	4.3551301	0.435513	2.1773
Error	12	2.4003214	0.200027	Prob > F
C. Total	22	6.7554515		0.1014

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.082598	0.260572	0.32	0.7567	0	.
# Lvl 3 Elements with EAC Data	0.0173387	0.007885	2.20	0.0482*	0.632838	2.7970384
RDT&E	0.4917713	0.251002	1.96	0.0737	0.442851	1.72547
Ordance	0.9115649	0.509883	1.79	0.0991	0.473938	2.3734167
CPAF	-0.044308	0.343916	-0.13	0.8996	-0.03762	2.8794365
CPIF	-0.46163	0.331802	-1.39	0.1894	-0.37403	2.4408633
FPIF	-0.132235	0.363262	-0.36	0.7222	-0.09248	2.1799065
Northrop Grumman Corporation	0.2559019	0.341407	0.75	0.4680	0.20734	2.5842139
Top 5 DOD Contractor	-0.553368	0.348049	-1.59	0.1378	-0.48631	3.1597044
Greater than 36	0.2728803	0.293683	0.93	0.3711	0.231681	2.0997045
% of Contract covered 50% - 75%	-0.091681	0.243527	-0.38	0.7131	-0.07784	1.443767

Effect Tests

Effect Details



Growth Definition #4 Bin - 25%

Thesis JMP File - Explanatory Variable #4 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Whole Model

Summary of Fit

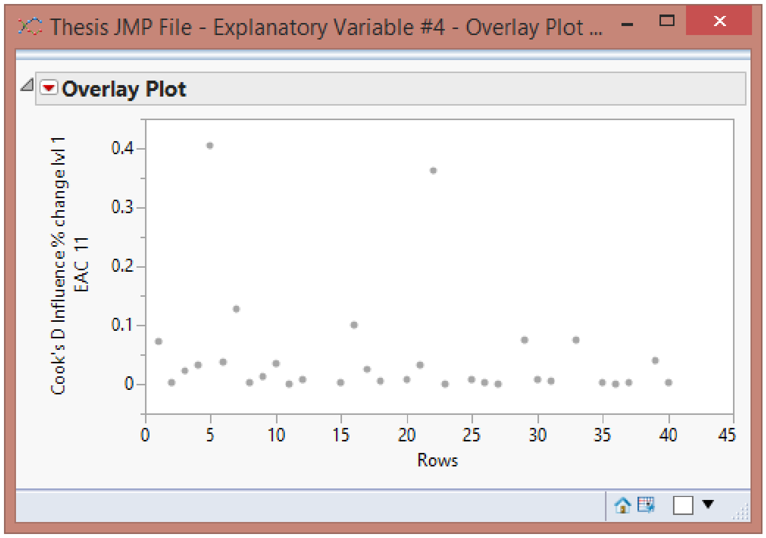
RSquare	0.55403
RSquare Adj	0.451114
Root Mean Square Error	0.550171
Mean of Response	0.5721
Observations (or Sum Wgts)	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	9.776815	1.62947	5.3833
Error	26	7.869904	0.30269	Prob > F
C. Total	32	17.646719		0.0010*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.9780012	0.198162	4.94	<.0001*	0	.
Unknown	-1.081331	0.590698	-1.83	0.0786	-0.25348	1.1178194
Air Force	0.8356391	0.334895	2.50	0.0193*	0.372957	1.302462
General Dynamics Corporation	0.1483375	0.360604	0.41	0.6842	0.058315	1.1716361
Top 3 DOD Contractor	-0.306669	0.233771	-1.31	0.2010	-0.20491	1.4224781
12 - 24 Months	-1.025001	0.199613	-5.13	<.0001*	-0.69794	1.0770417
% of Contract covered 50% - 75%	0.2508276	0.209404	1.20	0.2418	0.1676	1.1413875



Growth Definition #4 Bin – 30%

Thesis JMP File - Explanatory Variable #4 - Fit Least Squa...

Response % change lvl 1 EAC

Whole Model

Summary of Fit

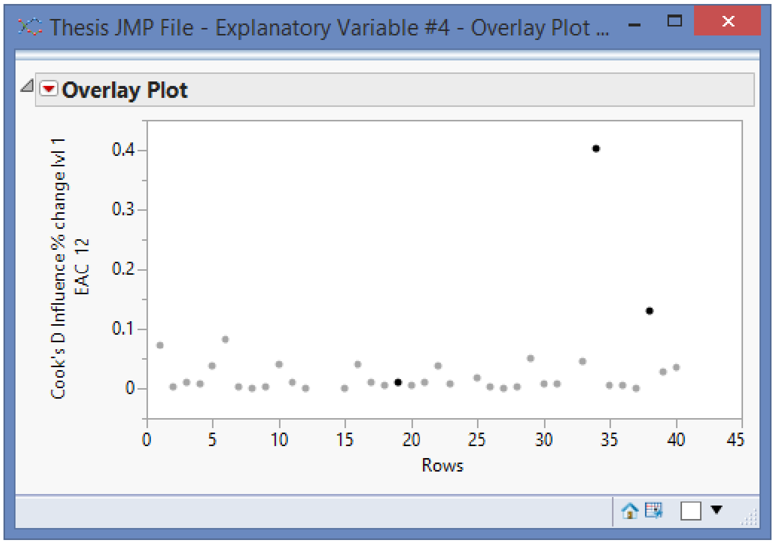
RSquare	0.071065
RSquare Adj	0.014766
Root Mean Square Error	1.062707
Mean of Response	0.742221
Observations (or Sum Wgts)	36

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	2.851081	1.42554	1.2623
Error	33	37.268428	1.12935	Prob > F
C. Total	35	40.119508		0.2963

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.3803675	0.313711	1.21	0.2339	0	.
CPAF	0.427138	0.39355	1.09	0.2856	0.186383	1.047619
Top 5 DOD Contractor	0.3470087	0.384565	0.90	0.3734	0.154956	1.047619


Thesis JMP File - Explanatory Variable #4 - Overlay Plot ...
Overlay Plot
Cook's D Influence % change lvl 1 EAC 12
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
40
45
Rows

Growth Definition #4 Bin - 35%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.949797
RSquare Adj	0.698785
Root Mean Square Error	0.503182
Mean of Response	0.769756
Observations (or Sum Wgts)	25

Analysis of Variance

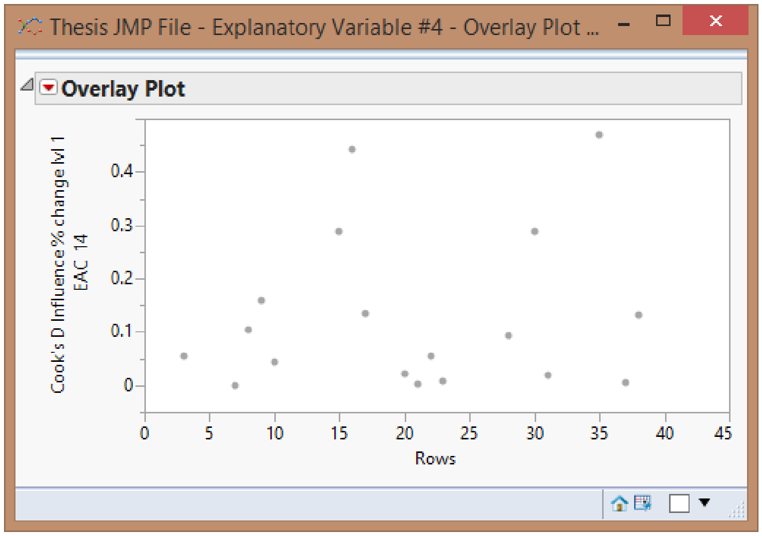
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	20	19.160847	0.958042	3.7839
Error	4	1.012767	0.253192	Prob > F
C. Total	24	20.173614		0.1026

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	-0.147145	0.657449	-0.22	0.8339	0	.
Total # Lvl 3 Elements	0.010807	0.005381	2.01	0.1150	0.321579	2.0425465
# Lvl 5 with EAC data elements <= 30	-0.207338	0.379643	-0.55	0.6140	-0.11307	3.4154896
ELECTRONIC/AUTOMATED SOFTWARE	0.573556	0.403973	1.42	0.2287	0.255396	2.5781849
Ordance	-0.29859	0.63404	-0.47	0.6622	-0.06514	1.524246
Ship	-0.044533	0.450875	-0.10	0.9261	-0.01817	2.6977499
Space	0.2287475	0.677558	0.34	0.7526	0.0499	1.740661
UAV	-0.300342	0.52503	-0.57	0.5979	-0.10865	2.8742409
Other 2	-0.193878	0.821102	-0.24	0.8249	-0.05855	4.8996159
CPAF	-0.20026	0.416466	-0.48	0.6557	-0.09521	3.1237354
CPIF	0.1033562	0.394512	0.26	0.8063	0.055228	3.5407277
Austal	-0.037358	0.948691	-0.04	0.9705	-0.00815	3.4124917
Bell-Boeing V-22 Program Office	0.2358035	0.823681	0.29	0.7889	0.051439	2.5724049
EG&G	0.037667	0.930557	0.04	0.9697	0.008217	3.2832771
Harris Corporation	1.3823297	0.827161	1.67	0.1700	0.301547	2.5941895
L-3 Communications	-0.214506	0.88916	-0.24	0.8212	-0.04679	2.9976518
Rockwell Collins, Inc.	-0.412871	0.912154	-0.45	0.6743	-0.09007	3.1546988
Telephonics Corporation	-0.333631	0.725644	-0.46	0.6696	-0.07278	1.9964961
Top 5 DOD Contractor	0.1458827	0.683076	0.21	0.8413	0.077951	10.614773
24 - 36	-0.945304	0.4598	-2.06	0.1090	-0.28549	1.5364069
Lvl 5 Cum Change / Final Lvl 1 EAC 35%	5.4204906	1.180813	4.59	0.0101*	0.873975	2.8881353

Effect Tests

Effect Details



Growth Definition #4 Bin - 40%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.991617
RSquare Adj	0.984166
Root Mean Square Error	0.116233
Mean of Response	0.74883
Observations (or Sum Wgts)	18

Analysis of Variance

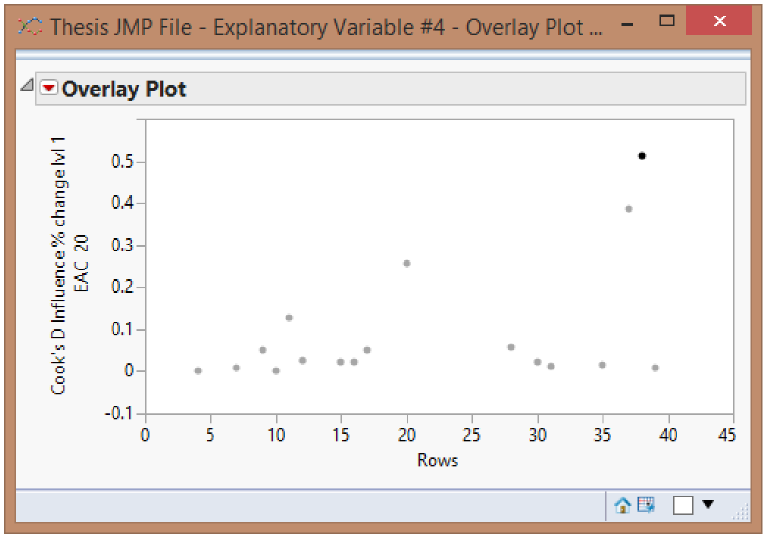
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	14.383262	1.79791	133.0793
Error	9	0.121590	0.01351	Prob > F
C. Total	17	14.504852		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.192195	0.060115	-3.20	0.0109*	0	.
Other		0.6083587	0.168439	3.61	0.0056*	0.155236	1.9833861
Air Force		0.3647384	0.09264	3.94	0.0034*	0.151424	1.5881179
ELECTRONIC/AUTOMATED SOFTWARE		0.6551209	0.124137	5.28	0.0005*	0.271979	2.851596
UAV		0.3389011	0.1005	3.37	0.0082*	0.140698	1.8690345
FPIF		0.2090361	0.100986	2.07	0.0684	0.073182	1.3419587
24 - 36		-1.126123	0.113793	-9.90	<.0001*	-0.39425	1.7039269
% of Contract covered 50% - 75%		0.3143528	0.071008	4.43	0.0017*	0.174008	1.6587157
Lvl 5 Cum Change / Final Lvl 1 EAC	40%	5.1763685	0.237882	21.76	<.0001*	0.864675	1.6952483

Effect Tests

Effect Details



Growth Definition #4 Bin - 45%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.60629
RSquare Adj	0.570499
Root Mean Square Error	0.594744
Mean of Response	0.876028
Observations (or Sum Wgts)	25

Analysis of Variance

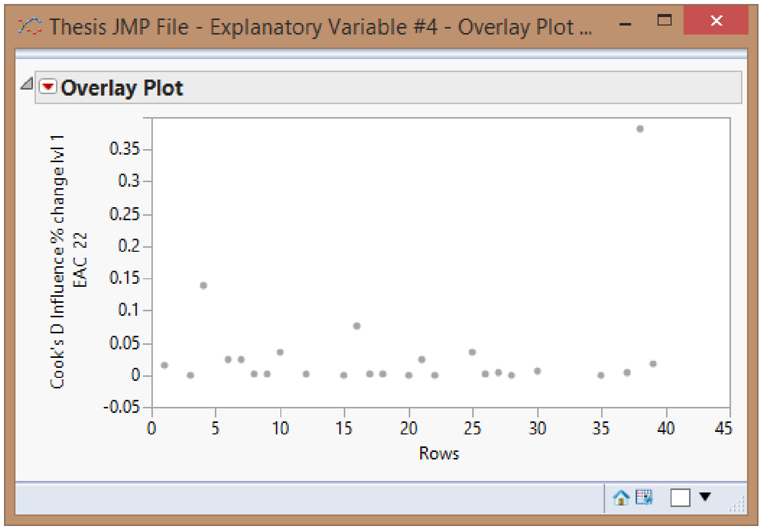
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	11.983595	5.99180	16.9394
Error	22	7.781846	0.35372	Prob > F
C. Total	24	19.765441		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.0288446	0.190369	0.15	0.8809	0	.
General Dynamics Corporation		1.370643	0.607283	2.26	0.0343*	0.302069	1.0009068
Lvl 3 Cum Change / Final Lvl 1 EAC	45%	3.6145707	0.665589	5.43	<.0001*	0.726816	1.0009068

Effect Tests

Effect Details



Growth Definition #4 Bin - 50%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.955606
RSquare Adj	0.947535
Root Mean Square Error	0.129672
Mean of Response	0.52029
Observations (or Sum Wgts)	14

Analysis of Variance

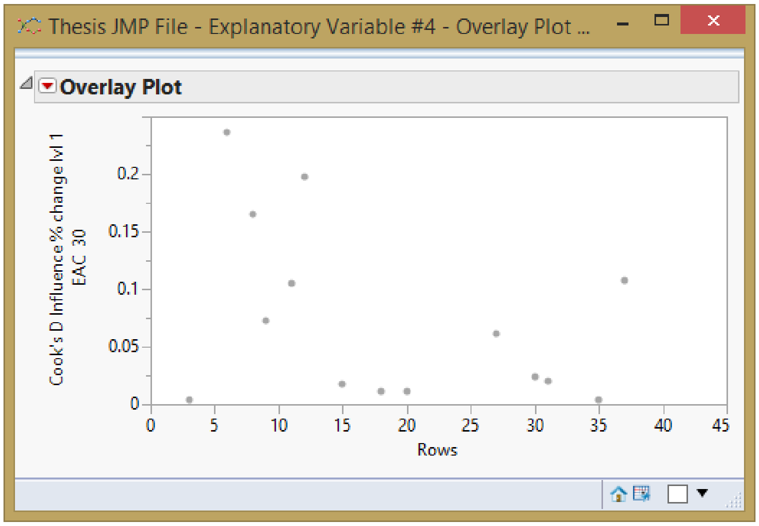
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	3.9815005	1.99075	118.3918
Error	11	0.1849643	0.01681	Prob > F
C. Total	13	4.1664647		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.006869	0.048854	-0.14	0.8907	0	.
Greater than 36		0.2572846	0.084783	3.03	0.0114*	0.225981	1.3740682
Lvl 5 Cum Change / Final Lvl 1 EAC	50%	2.6238456	0.232486	11.29	<.0001*	0.840445	1.3740682

Effect Tests

Effect Details



Growth Definition #4 Bin - 55%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.999476
RSquare Adj	0.998951
Root Mean Square Error	0.021725
Mean of Response	0.581216
Observations (or Sum Wgts)	15

Analysis of Variance

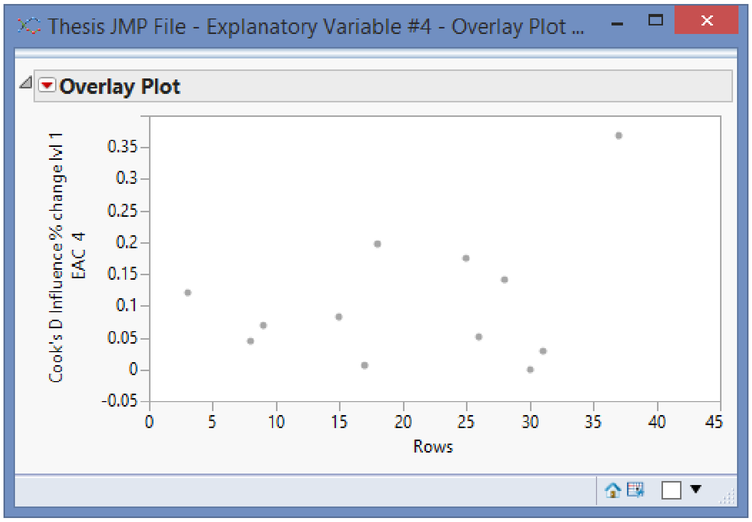
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	6.2958782	0.899411	1905.687
Error	7	0.0033037	0.000472	Prob > F
C. Total	14	6.2991819		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.073183	0.013803	-5.30	0.0011*	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	55%	2.4132104	0.044128	54.69	<.0001*	0.714805	2.2802469
# Lvl 5 with EAC data elements <= 30		0.0497127	0.018538	2.68	0.0315*	0.033924	2.1360127
Ordance		-0.129435	0.030879	-4.19	0.0041*	-0.04982	1.8856144
Other 2		0.5471308	0.026751	20.45	<.0001*	0.210604	1.4151295
CPFF		0.9081645	0.028908	31.42	<.0001*	0.349575	1.6525801
Top 3 DOD Contractor		0.0791745	0.01538	5.15	0.0013*	0.060953	1.8711487
Greater than 36		0.1624523	0.014454	11.24	<.0001*	0.12281	1.5936227

Effect Tests

Effect Details



Growth Definition #4 Bin - 60%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.992805
RSquare Adj	0.983211
Root Mean Square Error	0.123864
Mean of Response	0.896333
Observations (or Sum Wgts)	22

Analysis of Variance

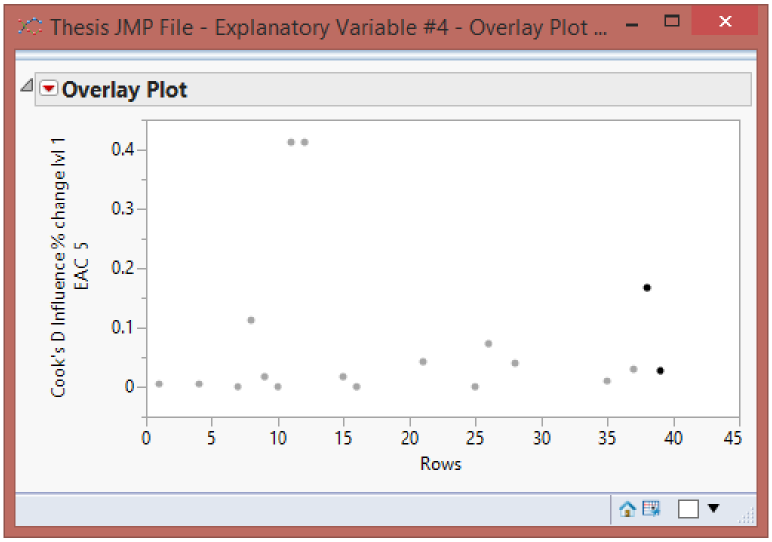
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	12	19.052874	1.58774	103.4875
Error	9	0.138081	0.01534	Prob > F
C. Total	21	19.190955		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.9432163	0.093159	10.12	<.0001*	0	.
Total # Lvl 5 Elements		-0.000107	3.278e-5	-3.27	0.0098*	-0.10783	1.3638991
Army		-1.130149	0.095458	-11.84	<.0001*	-0.5636	2.8346445
Aircraft		-0.953287	0.089282	-10.68	<.0001*	-0.45457	2.2671754
Missile		0.9722547	0.172794	5.63	0.0003*	0.216835	1.8576417
Ordance		0.5595486	0.131382	4.26	0.0021*	0.17223	2.0455761
CPFF		-0.399375	0.102767	-3.89	0.0037*	-0.12293	1.251571
EG&G		0.410347	0.147973	2.77	0.0216*	0.091517	1.3622987
General Dynamics Corporation		1.264318	0.139793	9.04	<.0001*	0.281972	1.215844
Harris Corporation		0.5489209	0.157413	3.49	0.0069*	0.122422	1.5416503
% of Contract covered < 25%		-1.003802	0.154124	-6.51	0.0001*	-0.22387	1.477895
% of Contract covered > 75%		-0.776873	0.067643	-11.48	<.0001*	-0.41417	1.6267043
Lvl 3 Cum Change / Final Lvl 1 EAC	60%	3.0568369	0.173482	17.62	<.0001*	0.736136	2.1831648

Effect Tests

Effect Details



Growth Definition #4 Bin - 65%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.880398
RSquare Adj	0.861998
Root Mean Square Error	0.184267
Mean of Response	0.399791
Observations (or Sum Wgts)	16

Analysis of Variance

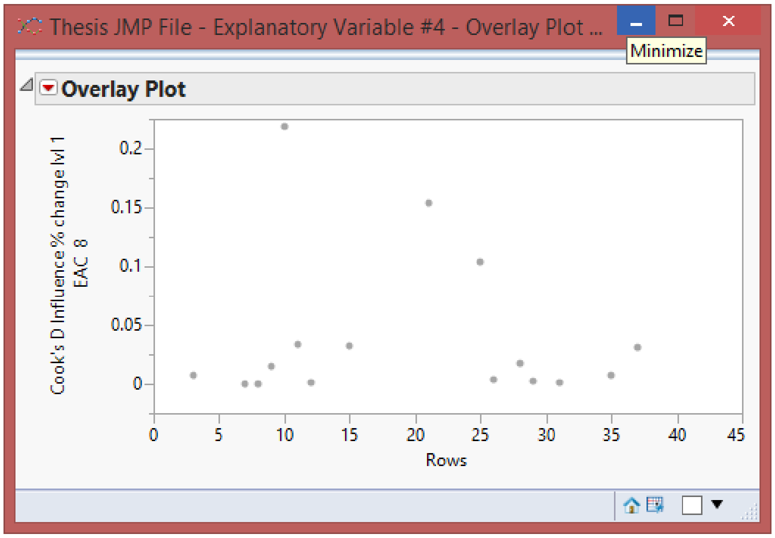
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	3.2492158	1.62461	47.8469
Error	13	0.4414058	0.03395	Prob > F
C. Total	15	3.6906215		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.037043	0.067153	-0.55	0.5906	0	.
Other 2		-0.337536	0.19032	-1.77	0.0996	-0.17012	1.0001052
Lvl 3 Cum Change / Final Lvl 1 EAC	65%	2.2611883	0.234614	9.64	<.0001*	0.924491	1.0001052

Effect Tests

Effect Details



Growth Definition #4 Bin - 70%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.038553
RSquare Adj	-0.03012
Root Mean Square Error	0.082868
Mean of Response	0.063699
Observations (or Sum Wgts)	16

Analysis of Variance

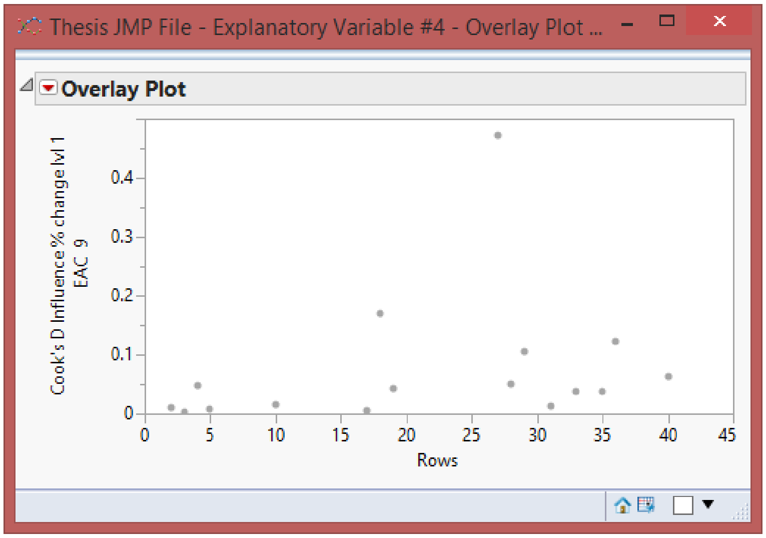
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00385513	0.003855	0.5614
Error	14	0.09613926	0.006867	Prob > F
C. Total	15	0.09999439		0.4661

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.0773886	0.027623	2.80	0.0141*	0	.
# Lvl 5 with EAC data elements <= 30	-0.03129	0.041762	-0.75	0.4661	-0.19635	1

Effect Tests

Effect Details



Growth Definition #4 Bin - 75%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.994196
RSquare Adj	0.987102
Root Mean Square Error	0.09541
Mean of Response	0.700753
Observations (or Sum Wgts)	21

Analysis of Variance

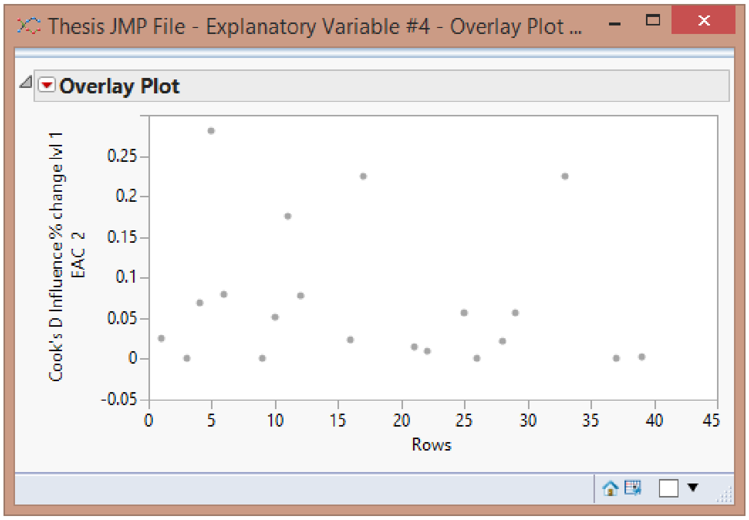
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	14.033377	1.27576	140.1460
Error	9	0.081928	0.00910	Prob > F
C. Total	20	14.115305		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.2780541	0.081161	3.43	0.0076*	0	.
# Lvl 5 with EAC data elements <= 30		-0.55098	0.058677	-9.39	<.0001*	-0.32636	1.8730843
Air Force		0.2577864	0.070861	3.64	0.0054*	0.12347	1.7861162
Navy		0.7823285	0.074612	10.49	<.0001*	0.476574	3.2033219
Aircraft		-1.288416	0.068453	-18.82	<.0001*	-0.66934	1.960961
Missile		-0.231453	0.09375	-2.47	0.0356*	-0.08287	1.7470908
UAV		-0.523581	0.124564	-4.20	0.0023*	-0.136	1.6233353
Northrop Grumman Corporation		-0.494873	0.068475	-7.23	<.0001*	-0.23702	1.6678711
Telephonics Corporation		0.224232	0.117733	1.90	0.0892	0.058245	1.4501696
Washington Demil Company		-0.441245	0.120896	-3.65	0.0053*	-0.11461	1.5291329
24 - 36		-0.876482	0.087954	-9.97	<.0001*	-0.3741	2.1852383
Lvl 3 Cum Change / Final Lvl 1 EAC	75%	2.9142983	0.118253	24.64	<.0001*	0.841867	1.8094387

Effect Tests

Effect Details



Growth Definition #4 Bin - 80%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.924452
RSquare Adj	0.893344
Root Mean Square Error	0.260376
Mean of Response	0.69402
Observations (or Sum Wgts)	25

Analysis of Variance

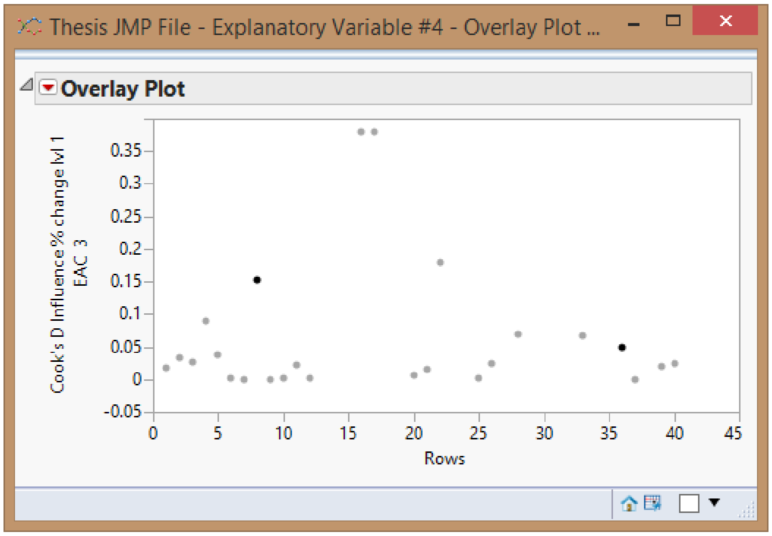
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	14.103023	2.01472	29.7176
Error	17	1.152524	0.06780	Prob > F
C. Total	24	15.255547		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		0.3680267	0.111576	3.30	0.0042*	0	.
Aircraft		-0.665264	0.133104	-5.00	0.0001*	-0.36372	1.1916438
Lockheed Martin Corporation		0.4215441	0.213954	1.97	0.0653	0.146399	1.2423948
Raytheon Company		-0.658754	0.153827	-4.28	0.0005*	-0.33732	1.3961251
Washington Demil Company		-0.787952	0.298247	-2.64	0.0171*	-0.19766	1.2595745
Top 3 DOD Contractor		-0.572206	0.133858	-4.27	0.0005*	-0.3516	1.5223413
Greater than 36		0.2964735	0.136884	2.17	0.0448*	0.189611	1.7246019
Lvl 3 Cum Change / Final Lvl 1 EAC	80%	2.4253323	0.268396	9.04	<.0001*	0.769095	1.6300296

Effect Tests

Effect Details



Growth Definition #4 Bin - 85%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.901075
RSquare Adj	0.89448
Root Mean Square Error	0.170752
Mean of Response	0.399814
Observations (or Sum Wgts)	17

Analysis of Variance

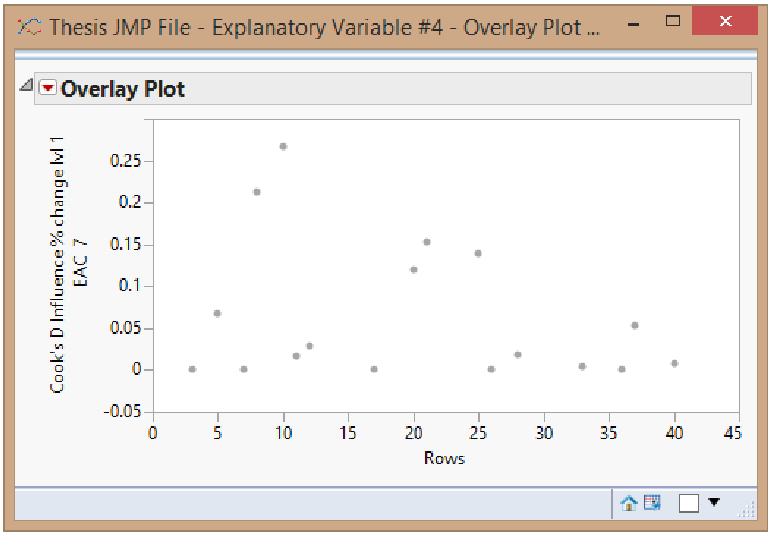
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.9836484	3.98365	136.6303
Error	15	0.4373461	0.02916	Prob > F
C. Total	16	4.4209946		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.060239	0.057133	-1.05	0.3084	0	.
Lvl 3 Cum Change / Final Lvl 1 EAC	85%	2.0945481	0.179191	11.69	<.0001*	0.94925	1

Effect Tests

Effect Details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Overlay Plot
Cook's D Influence % change lvl 1 EAC 7
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45
Rows

Growth Definition #4 Bin - 90%

Thesis JMP File - Growth Definition #4 - Fit Least Squares - JMP

Response % change lvl 1 EAC

Summary of Fit

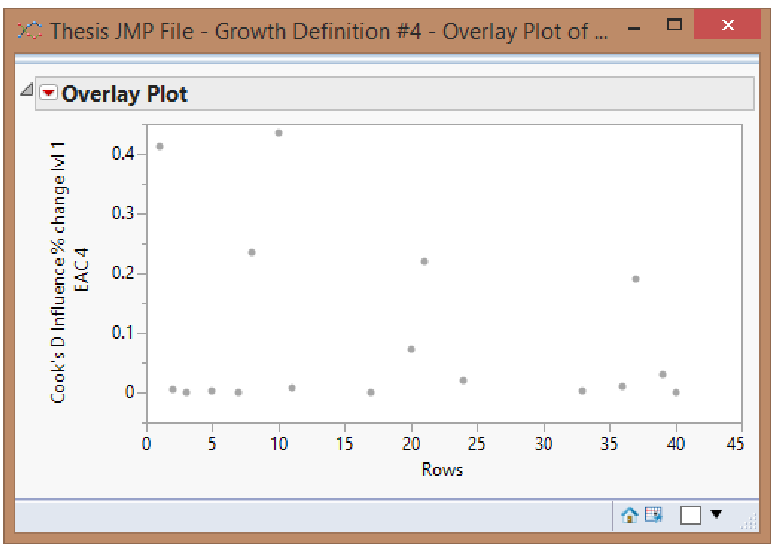
RSquare	0.919212
RSquare Adj	0.907671
Root Mean Square Error	0.213795
Mean of Response	0.519055
Observations (or Sum Wgts)	17

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	7.2810315	3.64052	79.6471
Error	14	0.6399134	0.04571	Prob > F
C. Total	16	7.9209449		<.0001*

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept		0.0525293	0.072963	0.72	0.4834	.
Lvl 3 Cum Change / Final Lvl 1 EAC	90%	0.328788	0.816418	0.40	0.6932	19.95766
Lvl 3 Cum Change / Final Lvl 1 EAC	90%^2	2.8553325	1.174438	2.43	0.0291*	19.95766



Growth Definition #4 Bin - 95%

Fit Model - JMP

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Response % change lvl 1 EAC

Summary of Fit

RSquare	0.857263
RSquare Adj	0.643157
Root Mean Square Error	0.460817
Mean of Response	0.748449
Observations (or Sum Wgts)	11

Analysis of Variance

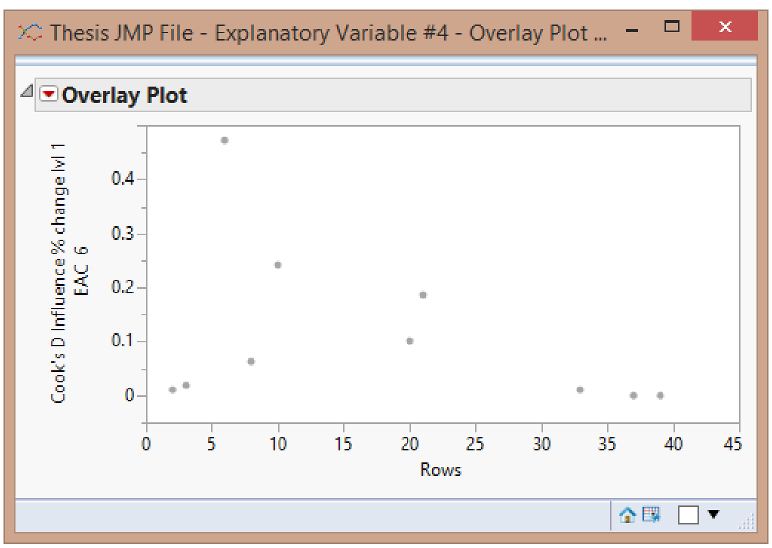
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	5.1014481	0.850241	4.0039
Error	4	0.8494100	0.212352	Prob > F
C. Total	10	5.9508581		0.1002

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept		-0.231805	0.408892	-0.57	0.6011	0	.
# Lvl 5 with EAC data elements > 30 and < 150		0.3698376	0.562267	0.66	0.5466	0.193937	2.4361707
Air Force		0.1980245	0.591794	0.33	0.7547	0.077399	1.4993079
CPAF		0.0254515	0.326016	0.08	0.9415	0.016646	1.2740462
Bell-Boeing V-22 Program Office		0.2037104	0.619473	0.33	0.7588	0.079621	1.6428357
Raytheon Company		-0.220824	0.383787	-0.58	0.5959	-0.13371	1.5133611
Lvl 3 Cum Change / Final Lvl 1 EAC	95%	2.6488262	0.877477	3.02	0.0392*	1.03354	3.2850449

Effect Tests

Effect Details



Growth Definition #4 Bin - 100%

Fit Model - JMP

Fit Group

Response % change lvl 1 EAC

Summary of Fit

RSquare	0.099865
RSquare Adj	0.006748
Root Mean Square Error	0.847865
Mean of Response	0.610653
Observations (or Sum Wgts)	33

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	2.312905	0.770968	1.0725
Error	29	20.847394	0.718876	Prob > F
C. Total	32	23.160300		0.3761

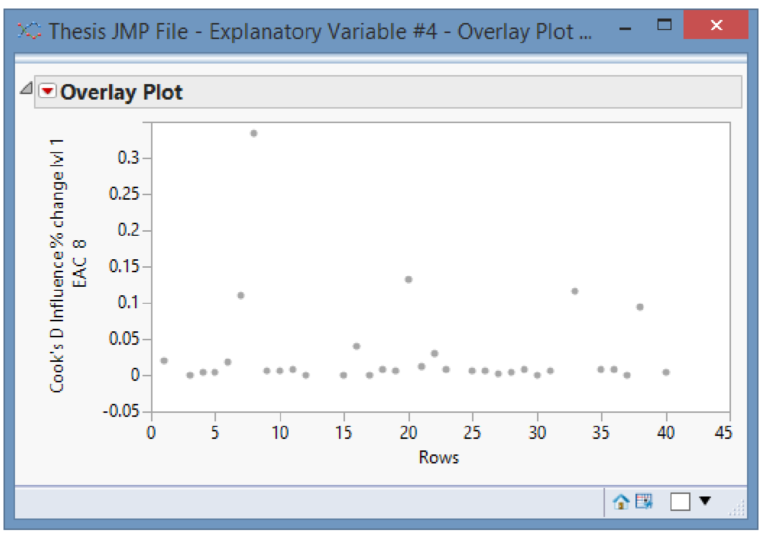
Lack Of Fit

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Std Beta	VIF
Intercept	0.6196499	0.184589	3.36	0.0022*	0	.
# Lvl 5 Elements with EAC Data	0.000296	0.000286	1.03	0.3097	0.185794	1.0401805
Missile	-0.014239	0.522303	-0.03	0.9784	-0.00489	1.0349491
FPIF	-0.523464	0.422443	-1.24	0.2252	-0.22404	1.0531635

Effect Tests

Effect Details

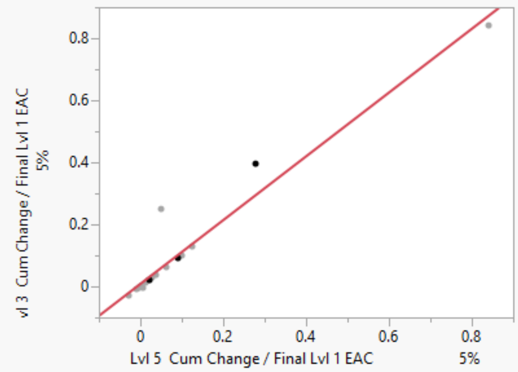


Appendix H – Relationship between Level Three and Level Five Data (Using Contractor's EAC or LRE

Comparing Level 3 with Level 5 at Bin - 5%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 Cu...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 5% By Lvl 5 Cum Change / Final Lvl 1 EAC 5%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 5% = 0.0121281 + 1.0280423*Lvl 5 Cum Change / Final Lvl 1 EAC 5%

Summary of Fit

RSquare	0.937588
RSquare Adj	0.934467
Root Mean Square Error	0.049916
Mean of Response	0.08823
Observations (or Sum Wgts)	22

Lack Of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.74860694	0.748607	300.4487
Error	20	0.04983259	0.002492	Prob > F
C. Total	21	0.79843953		<.0001*

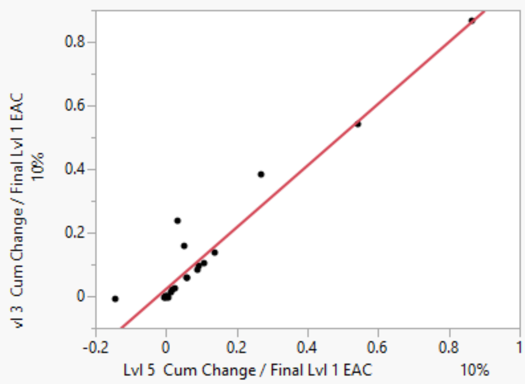
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0121281	0.011512	1.05	0.3047
Lvl 5 Cum Change / Final Lvl 1 EAC 5%	1.0280423	0.05931	17.33	<.0001*

Comparing Level 3 with Level 5 at Bin - 10%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 10% By Lvl 5 Cum Change / Final Lvl 1 EAC 10%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 10% = 0.0263214 + 0.971286*Lvl 5 Cum Change / Final Lvl 1 EAC 10%

Summary of Fit

RSquare	0.929937
RSquare Adj	0.926601
Root Mean Square Error	0.05773
Mean of Response	0.120197
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.92892381	0.928924	278.7301
Error	21	0.06998670	0.003333	Prob > F
C. Total	22	0.99891051		<.0001*

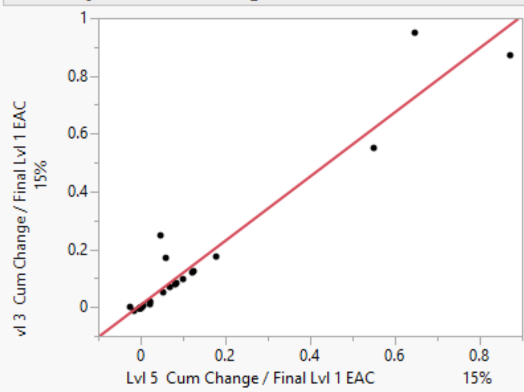
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0263214	0.013286	1.98	0.0608
Lvl 5 Cum Change / Final Lvl 1 EAC	10%	0.971286	0.058178	16.70	<.0001*

Comparing Level 3 with Level 5 at Bin - 15%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 15% By Lvl 5 Cum Change / Final Lvl 1 EAC 15%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 15% = 0.0115655 + 1.1112852*Lvl 5 Cum Change / Final Lvl 1 EAC 15%

Summary of Fit

RSquare	0.929004
RSquare Adj	0.925917
Root Mean Square Error	0.07084
Mean of Response	0.145304
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.5102970	1.51030	300.9598
Error	23	0.1154202	0.00502	Prob > F
C. Total	24	1.6257172		<.0001*

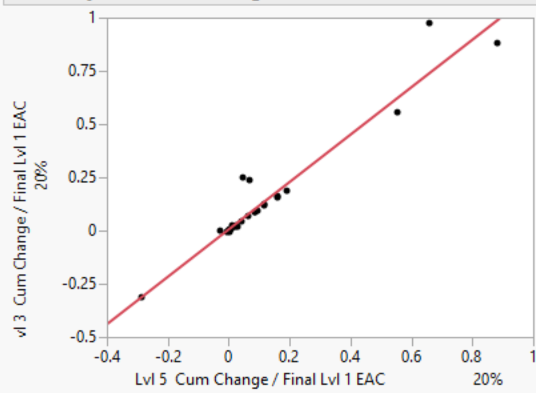
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0115655	0.016129	0.72	0.4806
Lvl 5 Cum Change / Final Lvl 1 EAC	15%	1.1112852	0.064058	17.35	<.0001*

Comparing Level 3 with Level 5 at Bin - 20%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 20% By Lvl 5 Cum Change / Final Lvl 1 EAC 20%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 20% = 0.011715 + 1.113232*Lvl 5 Cum Change / Final Lvl 1 EAC 20%

Summary of Fit

RSquare	0.928168
RSquare Adj	0.925405
Root Mean Square Error	0.071904
Mean of Response	0.136445
Observations (or Sum Wgts)	28

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.7369497	1.73695	335.9558
Error	26	0.1344245	0.00517	Prob > F
C. Total	27	1.8713742		<.0001*

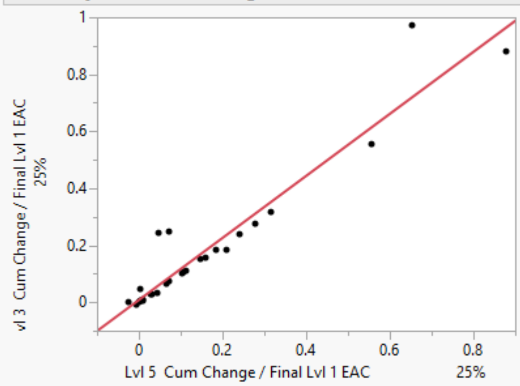
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.011715	0.015197	0.77	0.4477
Lvl 5 Cum Change / Final Lvl 1 EAC	20%	1.113232	0.060736	18.33	<.0001*

Comparing Level 3 with Level 5 at Bin - 25%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 25% By Lvl 5 Cum Change / Final Lvl 1 EAC 25%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 25% = 0.0125402 + 1.0884836*Lvl 5 Cum Change / Final Lvl 1 EAC 25%

Summary of Fit

RSquare	0.91159
RSquare Adj	0.90819
Root Mean Square Error	0.074793
Mean of Response	0.179641
Observations (or Sum Wgts)	28

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.4996601	1.49966	268.0841
Error	26	0.1454438	0.00559	Prob > F
C. Total	27	1.6451039		<.0001*

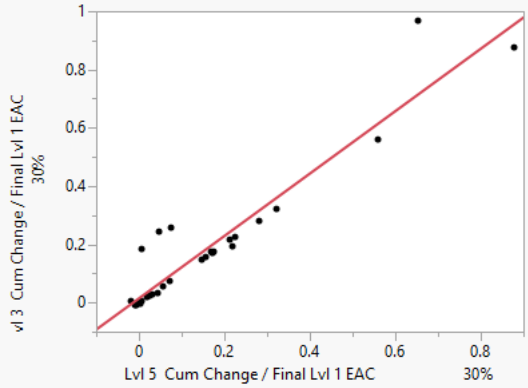
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0125402	0.017434	0.72	0.4784
Lvl 5 Cum Change / Final Lvl 1 EAC 25%	1.0884836	0.066479	16.37	<.0001*

Comparing Level 3 with Level 5 at Bin – 30%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 30% By Lvl 5 Cum Change / Final Lvl 1 EAC 30%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 30% = 0.0186728 + 1.0710517*Lvl 5 Cum Change / Final Lvl 1 EAC 30%

Summary of Fit

RSquare	0.894648
RSquare Adj	0.890746
Root Mean Square Error	0.08021
Mean of Response	0.185277
Observations (or Sum Wgts)	29

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.4751318	1.47513	229.2828
Error	27	0.1737093	0.00643	Prob > F
C. Total	28	1.6488411		<.0001*

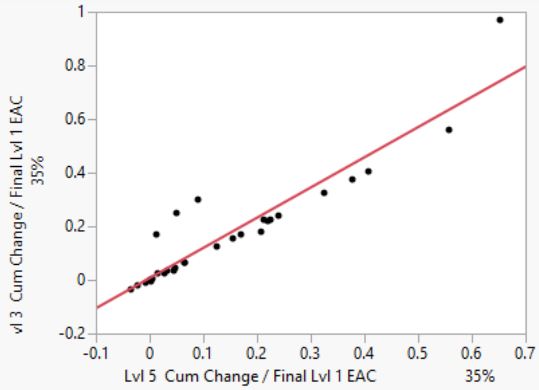
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0186728	0.018518	1.01	0.3222
Lvl 5 Cum Change / Final Lvl 1 EAC 30%	1.0710517	0.070733	15.14	<.0001*

Comparing Level 3 with Level 5 at Bin - 35%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 35% By Lvl 5 Cum Change / Final Lvl 1 EAC 35%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 35% = 0.0112382 + 1.1260621*Lvl 5 Cum Change / Final Lvl 1 EAC 35%

Summary of Fit

RSquare	0.863466
RSquare Adj	0.85841
Root Mean Square Error	0.080134
Mean of Response	0.176906
Observations (or Sum Wgts)	29

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0964873	1.09649	170.7535
Error	27	0.1733795	0.00642	Prob > F
C. Total	28	1.2698669		<.0001*

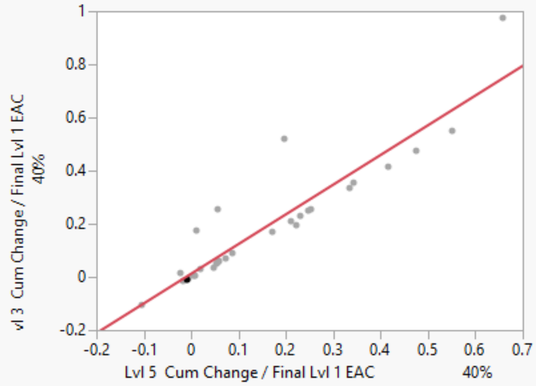
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0112382	0.019549	0.57	0.5701
Lvl 5 Cum Change / Final Lvl 1 EAC 35%	1.1260621	0.086174	13.07	<.0001*

Comparing Level 3 with Level 5 at Bin - 40%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 40% By Lvl 5 Cum Change / Final Lvl 1 EAC 40%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 40% = 0.0165462 + 1.1176128*Lvl 5 Cum Change / Final Lvl 1 EAC 40%

Summary of Fit

RSquare	0.850287
RSquare Adj	0.844742
Root Mean Square Error	0.090586
Mean of Response	0.194844
Observations (or Sum Wgts)	29

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.2583105	1.25831	153.3448
Error	27	0.2215555	0.00821	Prob > F
C. Total	28	1.4798659		<.0001*

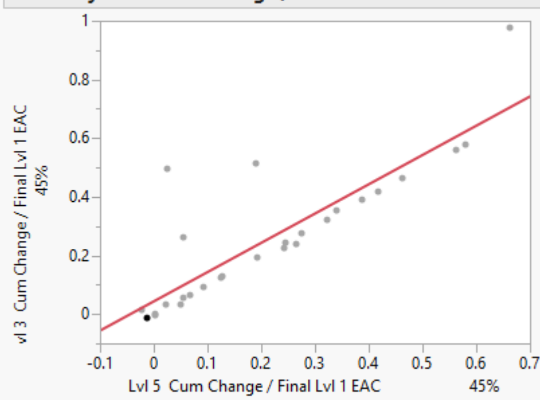
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0165462	0.022142	0.75	0.4614
Lvl 5 Cum Change / Final Lvl 1 EAC 40%	1.1176128	0.090252	12.38	<.0001*

Comparing Level 3 with Level 5 at Bin - 45%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 45% By Lvl 5 Cum Change / Final Lvl 1 EAC 45%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 45% = 0.0473537 + 0.9983099*Lvl 5 Cum Change / Final Lvl 1 EAC 45%

Summary of Fit

RSquare	0.719485
RSquare Adj	0.708696
Root Mean Square Error	0.125478
Mean of Response	0.265513
Observations (or Sum Wgts)	28

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0499695	1.04997	66.6868
Error	26	0.4093644	0.01574	Prob > F
C. Total	27	1.4593339		<.0001*

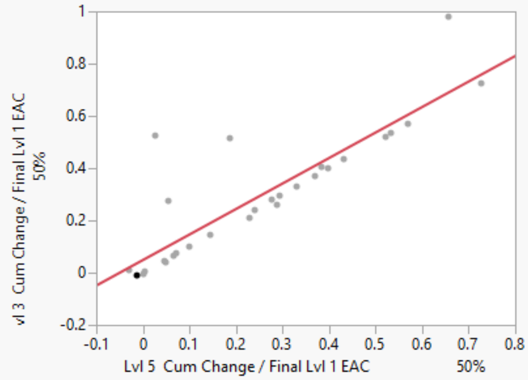
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0473537	0.035721	1.33	0.1965
Lvl 5 Cum Change / Final Lvl 1 EAC	45%	0.9983099	0.122249	8.17	<.0001*

Comparing Level 3 with Level 5 at Bin - 50%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 50% By Lvl 5 Cum Change / Final Lvl 1 EAC 50%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 50% = 0.0525985 + 0.9761492*Lvl 5 Cum Change / Final Lvl 1 EAC 50%

Summary of Fit

RSquare	0.742996
RSquare Adj	0.733477
Root Mean Square Error	0.128147
Mean of Response	0.287281
Observations (or Sum Wgts)	29

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.2818284	1.28183	78.0567
Error	27	0.4433876	0.01642	Prob > F
C. Total	28	1.7252160		<.0001*

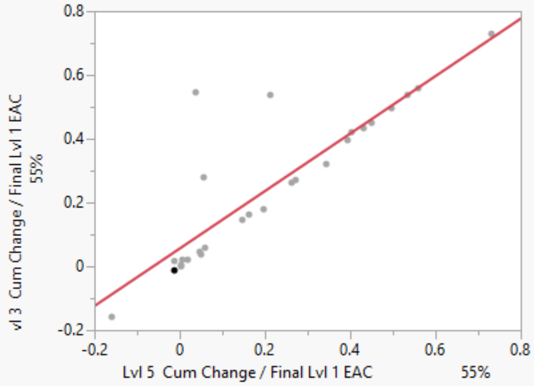
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0525985	0.035663	1.47	0.1518
Lvl 5 Cum Change / Final Lvl 1 EAC	50%	0.9761492	0.110487	8.83	<.0001*

Comparing Level 3 with Level 5 at Bin - 55%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 55% By Lvl 5 Cum Change / Final Lvl 1 EAC 55%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 55% = 0.0596322 + 0.9010143*Lvl 5 Cum Change / Final Lvl 1 EAC 55%

Summary of Fit

RSquare	0.756952
RSquare Adj	0.747604
Root Mean Square Error	0.118213
Mean of Response	0.258959
Observations (or Sum Wgts)	28

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.1315725	1.13157	80.9746
Error	26	0.3633348	0.01397	Prob > F
C. Total	27	1.4949072		<.0001*

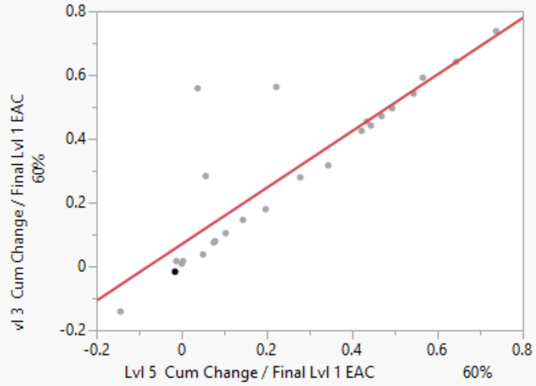
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0596322	0.03146	1.90	0.0692
Lvl 5 Cum Change / Final Lvl 1 EAC	55%	0.9010143	0.100128	9.00	<.0001*

Comparing Level 3 with Level 5 at Bin - 60%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 60% By Lvl 5 Cum Change / Final Lvl 1 EAC 60%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 60% = 0.0731927 + 0.8866092*Lvl 5 Cum Change / Final Lvl 1 EAC 60%

Summary of Fit

RSquare	0.751133
RSquare Adj	0.740313
Root Mean Square Error	0.127446
Mean of Response	0.292034
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.1275387	1.12754	69.4188
Error	23	0.3735788	0.01624	Prob > F
C. Total	24	1.5011175		<.0001*

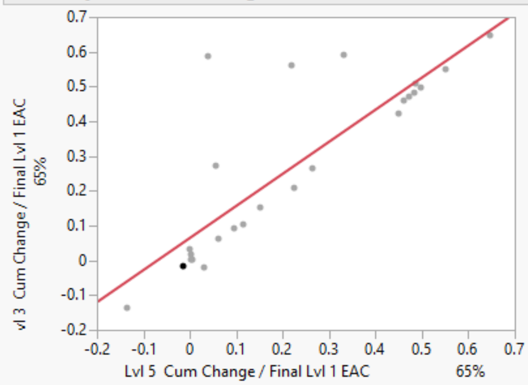
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0731927	0.0366	2.00	0.0575
Lvl 5 Cum Change / Final Lvl 1 EAC	60%	0.8866092	0.106413	8.33	<.0001*

Comparing Level 3 with Level 5 at Bin - 65%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 65% By Lvl 5 Cum Change / Final Lvl 1 EAC 65%



Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 65% = 0.0678536 + 0.9226451*Lvl 5 Cum Change / Final Lvl 1 EAC 65%

Summary of Fit

RSquare	0.695458
RSquare Adj	0.682768
Root Mean Square Error	0.13894
Mean of Response	0.265102
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0580056	1.05801	54.8068
Error	24	0.4633029	0.01930	Prob > F
C. Total	25	1.5213085		<.0001*

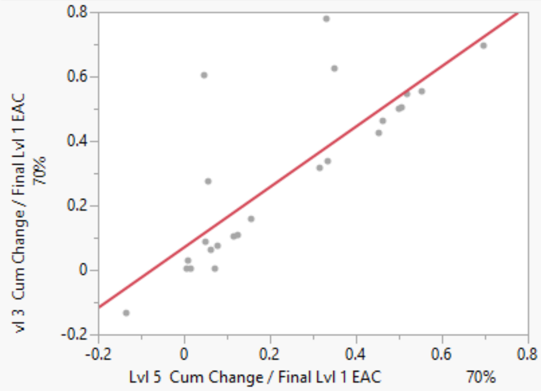
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0678536	0.03811	1.78	0.0877
Lvl 5 Cum Change / Final Lvl 1 EAC	65%	0.9226451	0.124629	7.40	<.0001*

Comparing Level 3 with Level 5 at Bin - 70%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 70% By Lvl 5 Cum Change / Final Lvl 1 EAC 70%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 70% = 0.0732381 + 0.9370974*Lvl 5 Cum Change / Final Lvl 1 EAC 70%

Summary of Fit

RSquare	0.665093
RSquare Adj	0.650532
Root Mean Square Error	0.154883
Mean of Response	0.304871
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0957100	1.09571	45.6758
Error	23	0.5517433	0.02399	Prob > F
C. Total	24	1.6474534		<.0001*

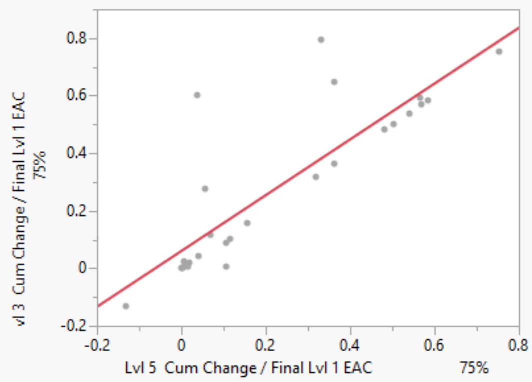
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0732381	0.046198	1.59	0.1265
Lvl 5 Cum Change / Final Lvl 1 EAC 70%	0.9370974	0.138657	6.76	<.0001*

Comparing Level 3 with Level 5 at Bin - 75%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 75% By Lvl 5 Cum Change / Final Lvl 1 EAC 75%



Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 75% = 0.0642079 + 0.9696422*Lvl 5 Cum Change / Final Lvl 1 EAC 75%

Summary of Fit

RSquare	0.705292
RSquare Adj	0.693013
Root Mean Square Error	0.15745
Mean of Response	0.28716
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.4238785	1.42388	57.4366
Error	24	0.5949704	0.02479	Prob > F
C. Total	25	2.0188490		<.0001*

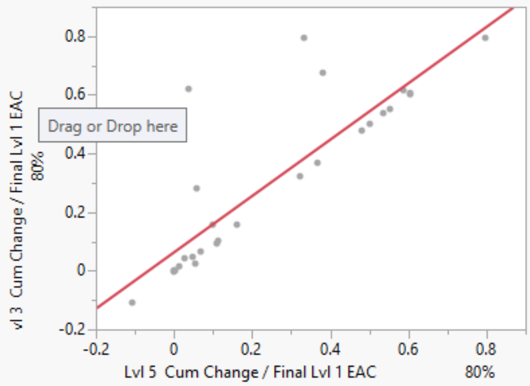
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0642079	0.042649	1.51	0.1452
Lvl 5 Cum Change / Final Lvl 1 EAC	75%	0.9696422	0.127943	7.58	<.0001*

Comparing Level 3 with Level 5 at Bin - 80%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 80% By Lvl 5 Cum Change / Final Lvl 1 EAC 80%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 80% = 0.0670415 + 0.9605577*Lvl 5 Cum Change / Final Lvl 1 EAC 80%

Summary of Fit

RSquare	0.728347
RSquare Adj	0.717899
Root Mean Square Error	0.151824
Mean of Response	0.298462
Observations (or Sum Wgts)	28

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.6068671	1.60687	69.7104
Error	26	0.5993157	0.02305	**Prob > F**
C. Total	27	2.2061828		<.0001*

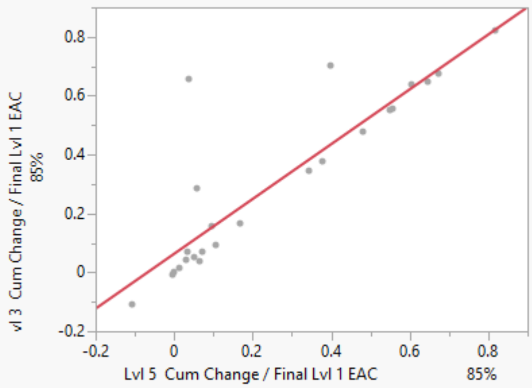
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0670415	0.039894	1.68	0.1048
Lvl 5 Cum Change / Final Lvl 1 EAC 80%	0.9605577	0.115047	8.35	<.0001*

Comparing Level 3 with Level 5 at Bin - 85%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 85% By Lvl 5 Cum Change / Final Lvl 1 EAC 85%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 85% = 0.0673173 + 0.9310231*Lvl 5 Cum Change / Final Lvl 1 EAC 85%

Summary of Fit

RSquare	0.76793
RSquare Adj	0.75784
Root Mean Square Error	0.142278
Mean of Response	0.293236
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.5406569	1.54066	76.1081
Error	23	0.4655891	0.02024	Prob > F
C. Total	24	2.0062460		<.0001*

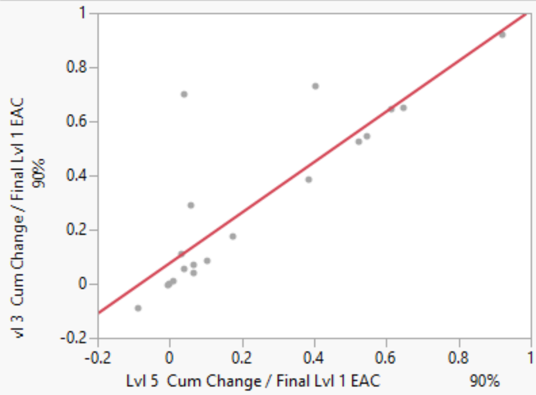
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0673173	0.038475	1.75	0.0935
Lvl 5 Cum Change / Final Lvl 1 EAC 85%	0.9310231	0.10672	8.72	<.0001*

Comparing Level 3 with Level 5 at Bin - 90%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 90% By Lvl 5 Cum Change / Final Lvl 1 EAC 90%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 90% = 0.0806797 + 0.9330587*Lvl 5 Cum Change / Final Lvl 1 EAC 90%

Summary of Fit

RSquare	0.725592
RSquare Adj	0.710347
Root Mean Square Error	0.169344
Mean of Response	0.292203
Observations (or Sum Wgts)	20

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.3649285	1.36493	47.5958
Error	18	0.5161947	0.02868	Prob > F
C. Total	19	1.8811232		<.0001*

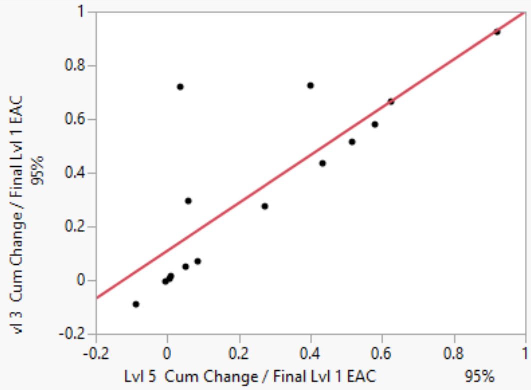
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0806797	0.048723	1.66	0.1151
Lvl 5 Cum Change / Final Lvl 1 EAC	90%	0.9330587	0.135246	6.90	<.0001*

Comparing Level 3 with Level 5 at Bin - 95%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 95% By Lvl 5 Cum Change / Final Lvl 1 EAC 95%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 95% = 0.1134328 + 0.8910782*Lvl 5 Cum Change / Final Lvl 1 EAC 95%

Summary of Fit

RSquare	0.664001
RSquare Adj	0.638155
Root Mean Square Error	0.198411
Mean of Response	0.344862
Observations (or Sum Wgts)	15

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0113635	1.01136	25.6906
Error	13	0.5117713	0.03937	Prob > F
C. Total	14	1.5231348		0.0002*

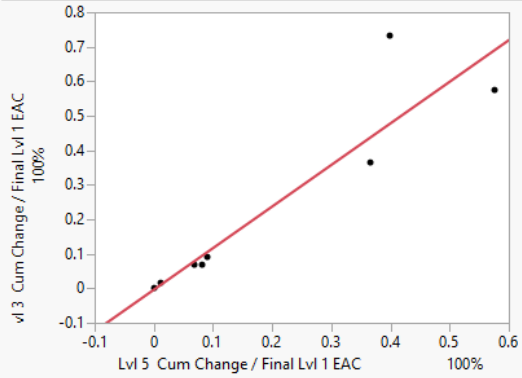
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1134328	0.068624	1.65	0.1223
Lvl 5 Cum Change / Final Lvl 1 EAC 95%	0.8910782	0.175804	5.07	0.0002*

Comparing Level 3 with Level 5 at Bin - 100%

Thesis JMP File - Explanatory Variable #4 - Fit Y by X of Lvl 3 Cu...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 100% By Lvl 5 Cum Change / Final Lvl 1 EAC 100%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 100% = -0.000444 + 1.2051882*Lvl 5 Cum Change / Final Lvl 1 EAC 100%

Summary of Fit

RSquare	0.850441
RSquare Adj	0.825515
Root Mean Square Error	0.117871
Mean of Response	0.239734
Observations (or Sum Wgts)	8

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.47401874	0.474019	34.1180
Error	6	0.08336118	0.013894	Prob > F
C. Total	7	0.55737992		0.0011*

Parameter Estimates

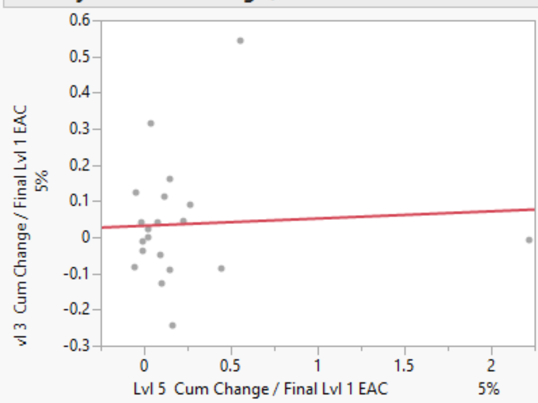
Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		-0.000444	0.058545	-0.01	0.9942
Lvl 5 Cum Change / Final Lvl 1 EAC	100%	1.2051882	0.20633	5.84	0.0011*

Appendix I – Relationship between Level Three and Level Five Data (Using Recalculated EAC)

Comparing Level 3 with Level 5 at Bin - 5%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 ...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 5% By Lvl 5 Cum Change / Final Lvl 1 EAC 5%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 5% = 0.033852 + 0.0200224*Lvl 5 Cum Change / Final Lvl 1 EAC 5%

Summary of Fit

RSquare	0.003454
RSquare Adj	-0.05191
Root Mean Square Error	0.172509
Mean of Response	0.038373
Observations (or Sum Wgts)	20

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00185673	0.001857	0.0624
Error	18	0.53566682	0.029759	Prob > F
C. Total	19	0.53752355		0.8056

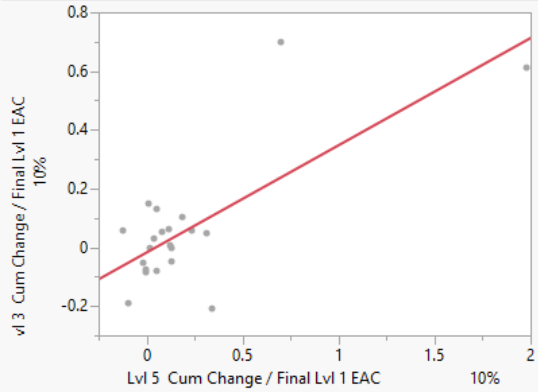
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.033852	0.04261	0.79	0.4373
Lvl 5 Cum Change / Final Lvl 1 EAC	5%	0.0200224	0.080159	0.25	0.8056

Comparing Level 3 with Level 5 at Bin - 10%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 10% By Lvl 5 Cum Change / Final Lvl 1 EAC 10%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 10% = -0.01376 + 0.365103*Lvl 5 Cum Change / Final Lvl 1 EAC 10%

Summary of Fit

RSquare	0.550533
RSquare Adj	0.526877
Root Mean Square Error	0.150358
Mean of Response	0.060363
Observations (or Sum Wgts)	21

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.52613054	0.526131	23.2723
Error	19	0.42954449	0.022608	Prob > F
C. Total	20	0.95567503		0.0001*

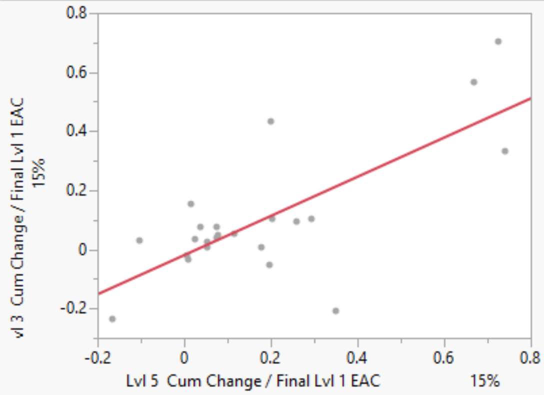
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.01376	0.03623	-0.38	0.7083
Lvl 5 Cum Change / Final Lvl 1 EAC 10%	0.365103	0.075683	4.82	0.0001*

Comparing Level 3 with Level 5 at Bin - 15%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 15% By Lvl 5 Cum Change / Final Lvl 1 EAC 15%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 15% = -0.016058 + 0.6629469*Lvl 5 Cum Change / Final Lvl 1 EAC 15%

Summary of Fit

RSquare	0.541233
RSquare Adj	0.519387
Root Mean Square Error	0.151765
Mean of Response	0.101754
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.5706341	0.570634	24.7749
Error	21	0.4836879	0.023033	Prob > F
C. Total	22	1.0543220		<.0001*

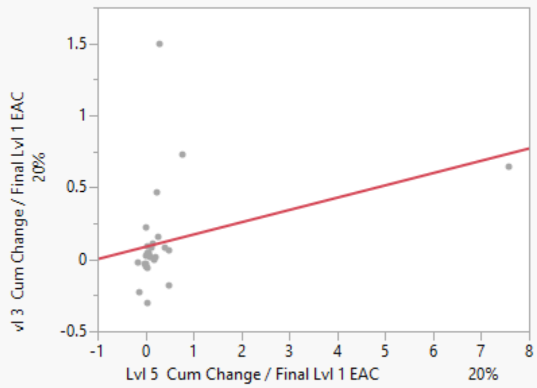
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.016058	0.039518	-0.41	0.6886
Lvl 5 Cum Change / Final Lvl 1 EAC 15%	0.6629469	0.13319	4.98	<.0001*

Comparing Level 3 with Level 5 at Bin - 20%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 20% By Lvl 5 Cum Change / Final Lvl 1 EAC 20%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 20% = 0.0928561 + 0.0854291*Lvl 5 Cum Change / Final Lvl 1 EAC 20%

Summary of Fit

RSquare	0.121328
RSquare Adj	0.084716
Root Mean Square Error	0.345547
Mean of Response	0.13025
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.3956918	0.395692	3.3139
Error	24	2.8656589	0.119402	Prob > F
C. Total	25	3.2613507		0.0812

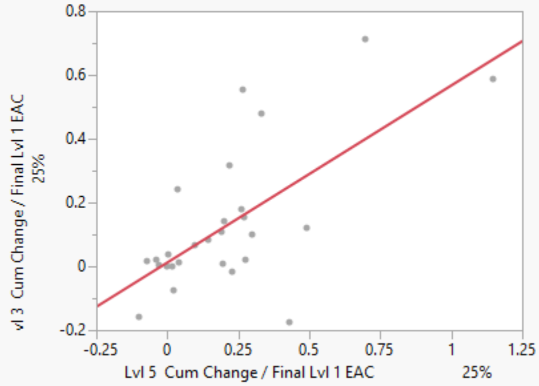
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0928561	0.070812	1.31	0.2022
Lvl 5 Cum Change / Final Lvl 1 EAC 20%	0.0854291	0.046928	1.82	0.0812

Comparing Level 3 with Level 5 at Bin - 25%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 25% By Lvl 5 Cum Change / Final Lvl 1 EAC 25%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 25% = 0.0156587 + 0.5550813*Lvl 5 Cum Change / Final Lvl 1 EAC 25%

Summary of Fit

RSquare	0.439583
RSquare Adj	0.417166
Root Mean Square Error	0.168663
Mean of Response	0.131168
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.5578396	0.557840	19.6096
Error	25	0.7111811	0.028447	Prob > F
C. Total	26	1.2690207		0.0002*

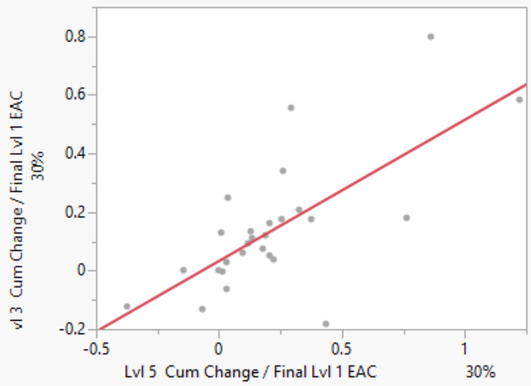
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0156587	0.041641	0.38	0.7101
Lvl 5 Cum Change / Final Lvl 1 EAC	25%	0.5550813	0.125349	4.43	0.0002*

Comparing Level 3 with Level 5 at Bin – 30%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 30% By Lvl 5 Cum Change / Final Lvl 1 EAC 30%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 30% = 0.0366075 + 0.4820336*Lvl 5 Cum Change / Final Lvl 1 EAC 30%

Summary of Fit

RSquare	0.491425
RSquare Adj	0.471082
Root Mean Square Error	0.159951
Mean of Response	0.140053
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.6180365	0.618036	24.1570
Error	25	0.6396050	0.025584	Prob > F
C. Total	26	1.2576415		<.0001*

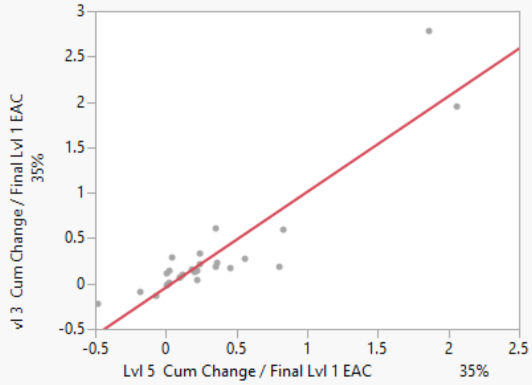
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0366075	0.03729	0.98	0.3357
Lvl 5 Cum Change / Final Lvl 1 EAC	30%	0.4820336	0.098075	4.91	<.0001*

Comparing Level 3 with Level 5 at Bin - 35%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 35% By Lvl 5 Cum Change / Final Lvl 1 EAC 35%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 35% = -0.030118 + 1.0521122*Lvl 5 Cum Change / Final Lvl 1 EAC 35%

Summary of Fit

RSquare	0.829056
RSquare Adj	0.822218
Root Mean Square Error	0.266168
Mean of Response	0.30769
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	8.589771	8.58977	121.2464
Error	25	1.771139	0.07085	Prob > F
C. Total	26	10.360910		<.0001*

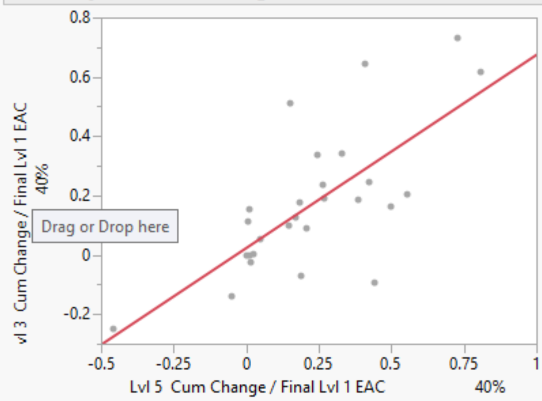
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.030118	0.059708	-0.50	0.6184
Lvl 5 Cum Change / Final Lvl 1 EAC 35%	1.0521122	0.095549	11.01	<.0001*

Comparing Level 3 with Level 5 at Bin - 40%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 40% By Lvl 5 Cum Change / Final Lvl 1 EAC 40%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 40% = 0.0266881 + 0.651423*Lvl 5 Cum Change / Final Lvl 1 EAC 40%

Summary of Fit

RSquare	0.51555
RSquare Adj	0.496172
Root Mean Square Error	0.169593
Mean of Response	0.171905
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.7652041	0.765204	26.6049
Error	25	0.7190445	0.028762	Prob > F
C. Total	26	1.4842486		<.0001*

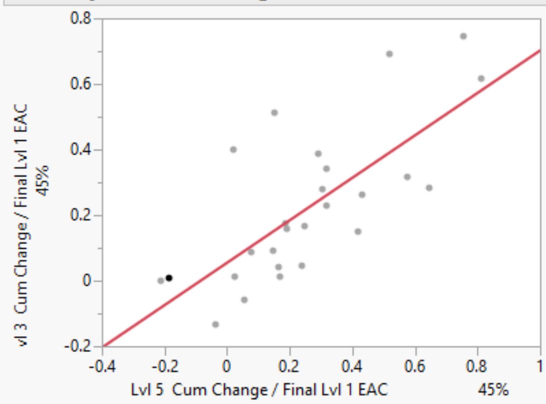
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0266881	0.043103	0.62	0.5414
Lvl 5 Cum Change / Final Lvl 1 EAC 40%	0.651423	0.126294	5.16	<.0001*

Comparing Level 3 with Level 5 at Bin - 45%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 45% By Lvl 5 Cum Change / Final Lvl 1 EAC 45%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 45% = 0.0586095 + 0.6470539*Lvl 5 Cum Change / Final Lvl 1 EAC 45%

Summary of Fit

RSquare	0.53128
RSquare Adj	0.51175
Root Mean Square Error	0.160886
Mean of Response	0.223695
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.7041419	0.704142	27.2033
Error	24	0.6212257	0.025884	Prob > F
C. Total	25	1.3253677		<.0001*

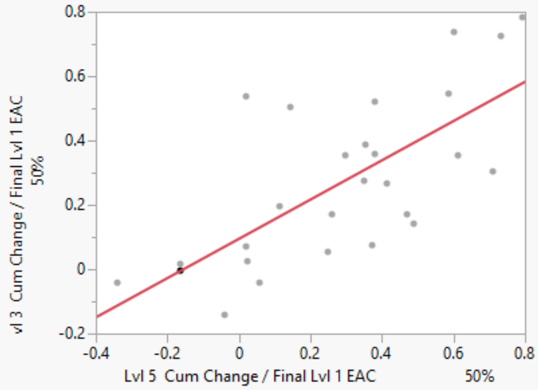
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0586095	0.044692	1.31	0.2021
Lvl 5 Cum Change / Final Lvl 1 EAC 45%	0.6470539	0.124059	5.22	<.0001*

Comparing Level 3 with Level 5 at Bin - 50%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 50% By Lvl 5 Cum Change / Final Lvl 1 EAC 50%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 50% = 0.097892 + 0.6101309*Lvl 5 Cum Change / Final Lvl 1 EAC 50%

Summary of Fit

RSquare	0.492837
RSquare Adj	0.472551
Root Mean Square Error	0.186769
Mean of Response	0.272233
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8474296	0.847430	24.2938
Error	25	0.8720621	0.034882	Prob > F
C. Total	26	1.7194917		<.0001*

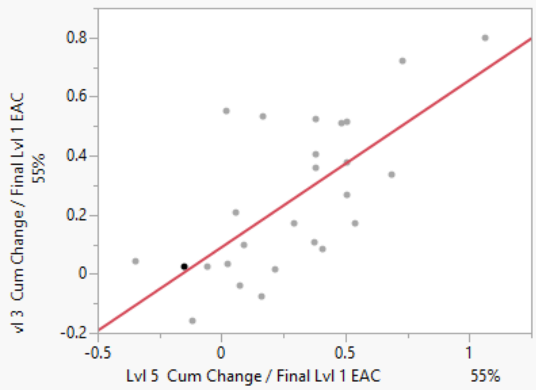
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.097892	0.050429	1.94	0.0636
Lvl 5 Cum Change / Final Lvl 1 EAC 50%	0.6101309	0.123787	4.93	<.0001*

Comparing Level 3 with Level 5 at Bin - 55%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 55% By Lvl 5 Cum Change / Final Lvl 1 EAC 55%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 55% = 0.093913 + 0.5652869*Lvl 5 Cum Change / Final Lvl 1 EAC 55%

Summary of Fit

RSquare	0.473166
RSquare Adj	0.451215
Root Mean Square Error	0.190296
Mean of Response	0.254153
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.7805652	0.780565	21.5551
Error	24	0.8690994	0.036212	Prob > F
C. Total	25	1.6496646		0.0001*

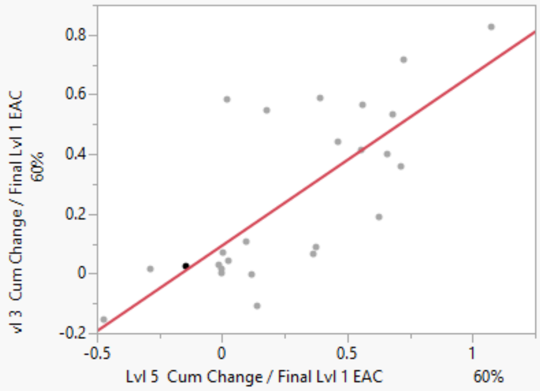
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.093913	0.050833	1.85	0.0770
Lvl 5 Cum Change / Final Lvl 1 EAC 55%	0.5652869	0.121757	4.64	0.0001*

Comparing Level 3 with Level 5 at Bin - 60%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 60% By Lvl 5 Cum Change / Final Lvl 1 EAC 60%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 60% = 0.0976531 + 0.5731404*Lvl 5 Cum Change / Final Lvl 1 EAC 60%

Summary of Fit

RSquare	0.558841
RSquare Adj	0.53966
Root Mean Square Error	0.192279
Mean of Response	0.254609
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0771643	1.07716	29.1353
Error	23	0.8503340	0.03697	Prob > F
C. Total	24	1.9274983		<.0001*

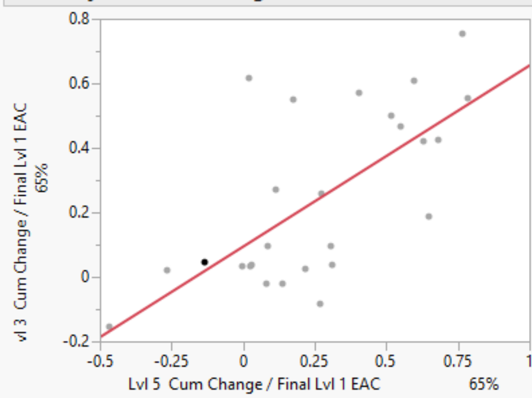
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0976531	0.048212	2.03	0.0546
Lvl 5 Cum Change / Final Lvl 1 EAC 60%	0.5731404	0.106182	5.40	<.0001*

Comparing Level 3 with Level 5 at Bin - 65%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 65% By Lvl 5 Cum Change / Final Lvl 1 EAC 65%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 65% = 0.0975418 + 0.5616182*Lvl 5 Cum Change / Final Lvl 1 EAC 65%

Summary of Fit

RSquare	0.459123
RSquare Adj	0.436586
Root Mean Square Error	0.20008
Mean of Response	0.243564
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8155428	0.815543	20.3724
Error	24	0.9607643	0.040032	Prob > F
C. Total	25	1.7763072		0.0001*

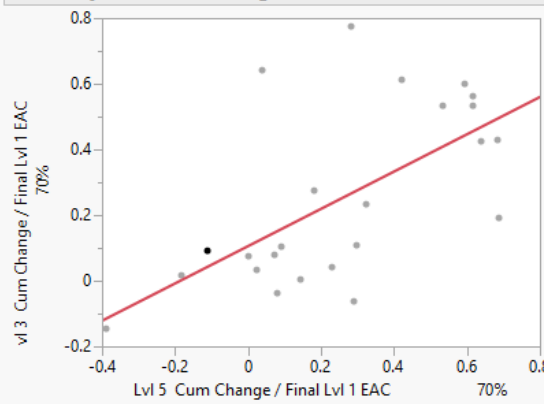
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0975418	0.050856	1.92	0.0671
Lvl 5 Cum Change / Final Lvl 1 EAC 65%	0.5616182	0.124429	4.51	0.0001*

Comparing Level 3 with Level 5 at Bin - 70%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 70% By Lvl 5 Cum Change / Final Lvl 1 EAC 70%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 70% = 0.108981 + 0.5679148*Lvl 5 Cum Change / Final Lvl 1 EAC 70%

Summary of Fit

RSquare	0.389802
RSquare Adj	0.362066
Root Mean Square Error	0.215532
Mean of Response	0.254742
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.6528592	0.652859	14.0539
Error	22	1.0219880	0.046454	Prob > F
C. Total	23	1.6748472		0.0011*

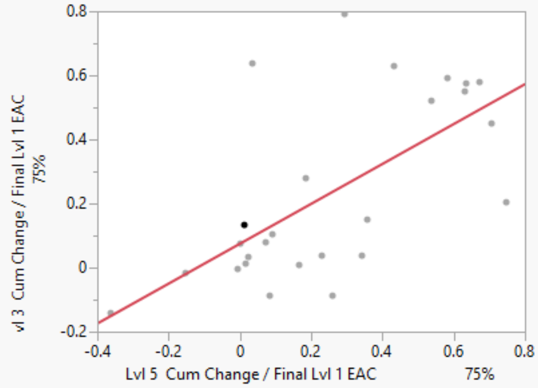
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.108981	0.058714	1.86	0.0769
Lvl 5 Cum Change / Final Lvl 1 EAC 70%	0.5679148	0.15149	3.75	0.0011*

Comparing Level 3 with Level 5 at Bin - 75%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 75% By Lvl 5 Cum Change / Final Lvl 1 EAC 75%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 75% = 0.0779742 + 0.6225855*Lvl 5 Cum Change / Final Lvl 1 EAC 75%

Summary of Fit

RSquare	0.417003
RSquare Adj	0.392712
Root Mean Square Error	0.219917
Mean of Response	0.235965
Observations (or Sum Wgts)	26

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8302361	0.830236	17.1666
Error	24	1.1607211	0.048363	Prob > F
C. Total	25	1.9909572		0.0004*

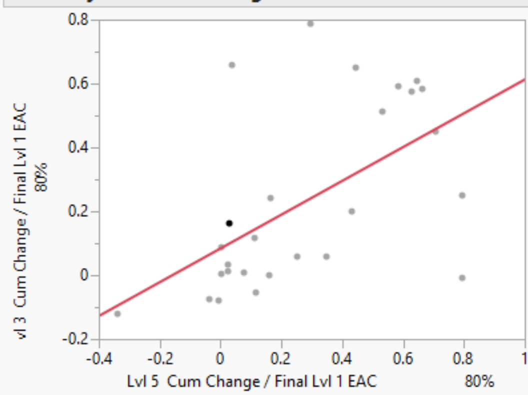
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0779742	0.057569	1.35	0.1882
Lvl 5 Cum Change / Final Lvl 1 EAC 75%	0.6225855	0.150265	4.14	0.0004*

Comparing Level 3 with Level 5 at Bin - 80%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 80% By Lvl 5 Cum Change / Final Lvl 1 EAC 80%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 80% = 0.0871898 + 0.5288341*Lvl 5 Cum Change / Final Lvl 1 EAC 80%

Summary of Fit

RSquare	0.321606
RSquare Adj	0.29447
Root Mean Square Error	0.238877
Mean of Response	0.23372
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.6762852	0.676285	11.8517
Error	25	1.4265516	0.057062	Prob > F
C. Total	26	2.1028368		0.0020*

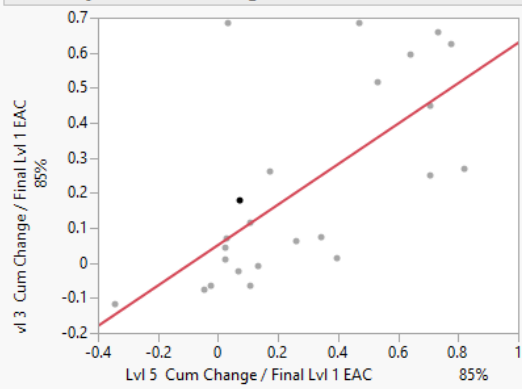
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0871898	0.06265	1.39	0.1763
Lvl 5 Cum Change / Final Lvl 1 EAC 80%	0.5288341	0.153613	3.44	0.0020*

Comparing Level 3 with Level 5 at Bin - 85%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 85% By Lvl 5 Cum Change / Final Lvl 1 EAC 85%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 85% = 0.0544207 + 0.5774634*Lvl 5 Cum Change / Final Lvl 1 EAC 85%

Summary of Fit

RSquare	0.455503
RSquare Adj	0.430753
Root Mean Square Error	0.207832
Mean of Response	0.216977
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.7949536	0.794954	18.4042
Error	22	0.9502697	0.043194	Prob > F
C. Total	23	1.7452233		0.0003*

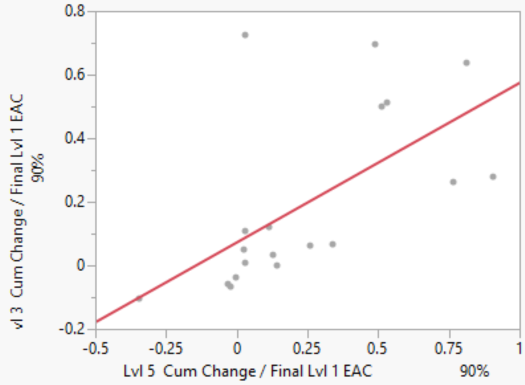
Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		0.0544207	0.056882	0.96	0.3491
Lvl 5 Cum Change / Final Lvl 1 EAC	85%	0.5774634	0.134606	4.29	0.0003*

Comparing Level 3 with Level 5 at Bin - 90%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 90% By Lvl 5 Cum Change / Final Lvl 1 EAC 90%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 90% = 0.0755054 + 0.5019414*Lvl 5 Cum Change / Final Lvl 1 EAC 90%

Summary of Fit

RSquare	0.372486
RSquare Adj	0.335574
Root Mean Square Error	0.225364
Mean of Response	0.19979
Observations (or Sum Wgts)	19

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.5125131	0.512513	10.0910
Error	17	0.8634121	0.050789	Prob > F
C. Total	18	1.3759252		0.0055*

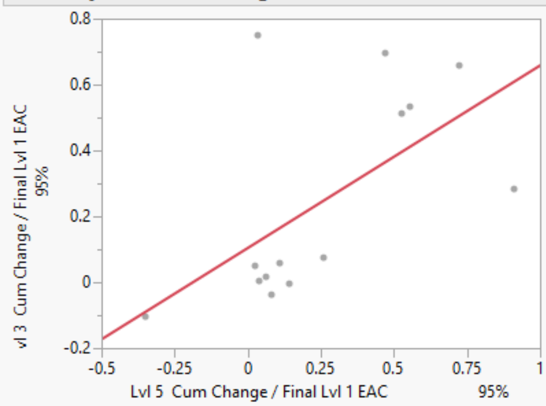
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0755054	0.064837	1.16	0.2603
Lvl 5 Cum Change / Final Lvl 1 EAC 90%	0.5019414	0.15801	3.18	0.0055*

Comparing Level 3 with Level 5 at Bin - 95%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 C...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 95% By Lvl 5 Cum Change / Final Lvl 1 EAC 95%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 95% = 0.1075214 + 0.5541605*Lvl 5 Cum Change / Final Lvl 1 EAC 95%

Summary of Fit

RSquare	0.35826
RSquare Adj	0.304781
Root Mean Square Error	0.2598
Mean of Response	0.249526
Observations (or Sum Wgts)	14

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.4521672	0.452167	6.6992
Error	12	0.8099544	0.067496	Prob > F
C. Total	13	1.2621216		0.0237*

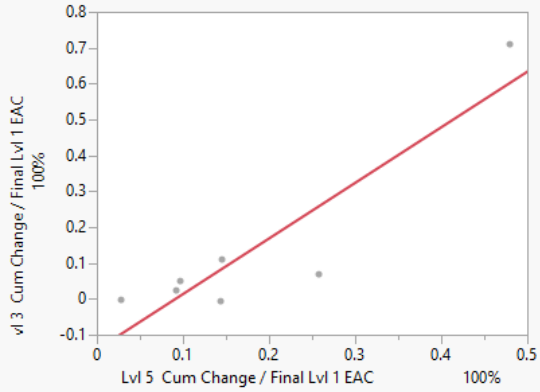
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1075214	0.088494	1.22	0.2477
Lvl 5 Cum Change / Final Lvl 1 EAC 95%	0.5541605	0.214104	2.59	0.0237*

Comparing Level 3 with Level 5 at Bin - 100%

Thesis JMP File - Explanatory Variable #3 - Fit Y by X of Lvl 3 Cu...

Bivariate Fit of Lvl 3 Cum Change / Final Lvl 1 EAC 100% By Lvl 5 Cum Change / Final Lvl 1 EAC 100%



Linear Fit

Linear Fit

Lvl 3 Cum Change / Final Lvl 1 EAC 100% = -0.13809 + 1.5495347*Lvl 5 Cum Change / Final Lvl 1 EAC 100%

Summary of Fit

RSquare	0.831208
RSquare Adj	0.797449
Root Mean Square Error	0.115112
Mean of Response	0.136796
Observations (or Sum Wgts)	7

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.32626349	0.326263	24.6222
Error	5	0.06625394	0.013251	Prob > F
C. Total	6	0.39251743		0.0042*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.13809	0.07044	-1.96	0.1072
Lvl 5 Cum Change / Final Lvl 1 EAC 100%	1.5495347	0.312276	4.96	0.0042*

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14. ABSTRACT
Contract cost growth has been a concern for the Department of Defense (DoD) for decades. Earned value management is a tool used by the DoD to assist in identifying cost overruns before they occur. Current DoD regulations require contracts to report their earned value management (EVM) data down to level three of the work breakdown structure (WBS). Previous research has shown level three EVM data can predict contract cost growth earlier than using level one EVM data. Our research examines if level five EVM data would better predict cost growth than level three. Our results indicate that level five is not a better predictor of cost growth then level three. Our results do not support the DoD requiring contractors to provide level five EVM data.

15. SUBJECT TERMS
Work Breakdown Structure, Earned Value Management, Lower Level, Cost Growth

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U	**U**	**U**	**UU**	230	**19b. TELEPHONE NUMBER** *(Include area code)* (937) 255-3636, ext 4540 Edward.White@afit.edu