3-23-2017

An Analysis of Forecasting Methods on Supply Discrepancy Reporting

Cody S. Freeborn

AN ANALYSIS OF FORECASTING METHODS ON SUPPLY DISCREPANCY REPORTING

THESIS
MARCH 2017

Cody S. Freeborn, Captain, USAF

AFIT-ENS-MS-17-M-130

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT-ENS-MS-17-M-130

AN ANALYSIS OF FORECASTING METHODS ON SUPPLY DISCREPANCY REPORTING

THESIS

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics and Supply Chain Management

Cody S. Freeborn, BS

Captain, USAF

March 2017

AFIT-ENS-MS-17-M-130

AN ANALYSIS OF FORECASTING METHODS ON SUPPLY DISCREPANCY REPORTING

Cody S. Freeborn, BS

Captain, USAF

Committee Membership:

Dr. Michael Kretser
Chair (Primary Research Advisor)

Dr. Alan Johnson
Member

Abstract

The Department of Defense (DoD) tracks and records all cargo shipments as they move from one location to the next. Inevitably, there are mistakes that are made when dealing with these shipments. Currently the Air Force does not use any forecasting techniques to predict these shipping discrepancies, thus it has no way to prepare for them other than employing remedial measures after errors occur.

The purpose of this research is to study the current Air Force shipping processes, specifically shipping discrepancies, and determine if any trends emerge. By examining historical shipment discrepancy data, a trend analysis was accomplished and from this data a relatively accurate forecast was developed.

In the final analysis, it was concluded that three models most accurately forecasted the behavior of the discrepancy codes studied. These three models can be utilized in determining the root causes of these discrepancy trends. If employed, focused training events should reduce costs to the Air Force through cost avoidance through by circumventing lost time and resources normally expended correcting shipping errors.

Acknowledgments

I would like to express my sincere appreciation to my faculty advisor, Capt Michael Kretser, for his guidance and support throughout the course of this thesis effort. The insight and experience was certainly appreciated. I would, also, like to thank my sponsor, Ms. Linda Lowin, from the Air Force Installation and Mission Support Center for both the support and latitude provided to me in this endeavor.

Cody S. Freeborn

Table of Contents

List of Figures

Page

List of Tables

Page

AN ANALYSIS OF FORECASTING METHODS ON SUPPLY DISCREPANCY REPORTING

I. Introduction

Purpose

The Department of Defense (DoD) tracks and records all cargo shipments as they move from one location to the next. The information collected is vast and includes details about each item, not only the origin and destination, but also any important details about the shipment. Inevitably, there are mistakes that are made when dealing with these shipments. Shipping errors can be as simple as improper labeling, or can be as disastrous as shipping the wrong item or shipping to the incorrect location. Currently the Air Force does not use any forecasting techniques to predict these shipping discrepancies, thus it has no way to prepare for them other than employing remedial measures after errors occur. This research will focus on determining whether traditional forecasting techniques are capable of forecasting these shipping discrepancies or if new techniques need to be developed.

The purpose of this research is to study the current Air Force shipping processes, specifically shipping discrepancies, and determine if any trends emerge. By examining historical shipment discrepancy data, a trend analysis was accomplished and from this data a relatively accurate forecast was developed. The ability to forecast the discrepancies that impact the Air Force the most will allow managers to prepare for these errors and eventually be able to prevent or reduce the number of them from happening.

Background

All shipping errors that the DoD observes are recorded as Shipping Discrepancy Reports (SDRs). An SDR is a tool used to report shipping or packaging discrepancies attributable to the responsibility of the shipper, and to provide appropriate responses and resolution, including financial action when appropriate. The purpose of the SDR exchange is to determine the cause of such discrepancies, effect corrective action, and prevent recurrence. All SDRs are tracked and maintained on a web based application called DoD WebSDR. DoD WebSDR is an application that enables SDR transaction exchange, provides a web-based entry method, and provides visibility of SDRs for research and trend analysis via management report/query capability. It is essentially a large database in which all SDRs are maintained. This was the source of all quantitative data used for this research.

The Air Force Installation and Mission Support Center (AFIMSC) Traffic Management section is responsible for the majority of the SDR process. The entire process was originally owned by the Material Management section, but was transferred to the Traffic Management section when the inbound cargo receiving and receipt functions were combined. Material Management still maintains a role however, due to many of the reasons for discrepancies originating from inventory and stock control issues. Therefore, the combined effort of these two sections will be manifested in the form of a functional project with the goal to reduce overall discrepancies. Because of the large amount of discrepancies that occur each year, Traffic Management intends to identify specific and controllable discrepancies from an enterprise view. This will enable them to pinpoint which agencies are responsible for these discrepancies and ensure that proper training is conducted in order to reduce future errors.

Problem

Currently the Supply Discrepancy Reporting process is managed and affected by two different offices. Neither of these offices are conducting effective preventative measures to reduce discrepancies, and neither of them are communicating issues well because they are not aware of what issues they have. Due to these reasons, the Air Force has no way to accurately predict when and where discrepancies will occur.

The current SDR database is a cumbersome system that proves difficult to use or to pull valuable information from. The system is designed to provide individual discrepancy information as well as enterprise level discrepancy trend data. Unfortunately, the system is best used on a case-by-case basis to gain information on specific discrepancies, but is not designed to inform users of any discrepancy trends. Managers do not have an accurate picture of what discrepancies are on an upward trend, downward trend, or which locations are the most common culprits of these mistakes.

AFIMSC is continually working to reduce supply discrepancies, but in order to make progress it needs to pinpoint the root cause of these discrepancies. Currently it is not equipped to make these determinations. This analysis will assist managers in identifying the problem areas and provide AFIMSC a plan of action to correct these mistakes.

Justification

Shipping errors cost the Air Force and the DoD time and money. Currently the Air Force does not have an effective method for tracking these discrepancies to their root causes. If this research can help pinpoint at least some of the origins of these shipping discrepancies it will result in a reduced number of SDRs. Once these causes have been identified, the Air Force will

be able to apply corrective action, not only at problem areas, but at Traffic Management Offices around the world. Implementing a change like this will reduce overall costs and improve shipping efficiency across the Air Force.

Assumptions

This research is limited by the available quantitative data, which is accessed through the WebSDR database. This research assumes that the data pulled from WebSDR has been recorded correctly and accurately represents the SDR historical record. WebSDR is maintained under the Defense Logistics Management Standards, which provides a base of business rules, data standards, and electronic business objects designed to meet DoD's requirements for total logistics support. This research assumes that under the purview of DLMS, WebSDR records are maintained correctly.

Scope

This study focused on the total number of Air Force shipment discrepancies for specific discrepancy codes. The decision to exclude location information of each discrepancy was conducted to allow for the researcher to focus on one specific variable; the discrepancy code itself. In order to complete the study in a timely manner two groups of SDRs were analyzed. After studying the most common discrepancies over the last three years, the top five most common discrepancy codes were selected for the study. At the request of the AFIMSC, a similar selection process was completed for the top five most common packaging discrepancy codes. One of the top packaging discrepancy codes was also one of the top overall discrepancy codes. These two groups (9 total codes) are the focus of this research.

Methodology

Data for this research was collected from the WebSDR database. Data for each of the 9 discrepancy codes were collected in monthly increments and include a five year historical record. Once these time series data were compiled, a thorough forecasting analysis was conducted. The statistical tools used to conduct this analysis were MS Excel and JMP.

Research Objectives

The primary objective of this research is to identify the most costly and most common SDRs the Air Force currently deals with and create forecasting models to assist Traffic Managers in predicting and reducing SDRs.

Also, as a result of this research, many different forecasting models were tested on this data. Based on the results of these tests, this study will recommend specific forecasting techniques for Traffic Managers to use in the future.

Research Questions

In order to address the objective listed above, the following questions were established and will be answered during the course of this research:

- How can the Air Force better forecast SDRs?
- How can the Air Force assess the validity of these forecasts?
- How can forecasting help to reduce supply discrepancies?

Organization

Chapter I provides an introduction to the topic of the study as well as the necessary background information the reader will need to establish a foundation which the following chapters will build upon. This chapter also provides an overview of the problem, methodology, scope, and research objectives/questions.

Chapter II gives a literature review on shipping errors in the Air Force and how large their impact can be. Also included here is an analysis of the various forecasting concepts which are used in this study.

Chapter III details the specific methods used in this study to collect data, conduct a statistical analysis, and the parameters chosen to test the validity of these results.

Chapter IV reviews the results of the analysis that was detailed in Chapter III. This chapter aims to answer the research questions presented and to determine the validity of the tests themselves.

Chapter V discusses the results of the study and presents the conclusions and recommendations for further research in this field.

II. Literature Review

Overview

This chapter discusses the history the Air Force has with shipping errors and how these errors have a lasting impact on the military. An introduction to forecasting techniques and concepts is provided as well. Literature on shipping discrepancies is explored and the benefits of combining forecasting with traffic management is discussed.

Air Force Shipment Errors

Shipping errors can have large implications depending on what is being shipped and which parties are involved. Shipping the wrong item or shipping to the wrong location can be disastrous for the Air Force and the DoD. A mistake like this could result in the loss of classified weapons or material to the enemies of the United States, which is why conducting proper shipment precautions is extremely important. In the mid 2000's, the USAF committed two very serious mistakes that involved the handling and shipment of nuclear weapons.

The first incident took place on August 31, 2007, as "a U.S. Air Force B-52 plane with the call sign "Doom 99" took off from Minot AFB, North Dakota, inadvertently loaded with six Advanced Cruise Missiles loaded with nuclear warheads and flew to Barksdale AFB, Louisiana. After landing, "Doom 99" sat on the tarmac at Barksdale unguarded for nine hours before the nuclear weapons were discovered"(Spencer et al., 2012). The decision to move these cruise missiles from Minot AFB to Barksdale AFB was part of an Air Force re-positioning program. Since these two bases are the only bomber wings that currently support the B-52 airframe, flights

between these two locations are fairly regular for the bomber squadrons. Therefore, if munitions need to be moved from one base to the other, the Air Force can save money by loading the munitions in the bomb bay of an aircraft that is departing to the other base rather than requiring a cargo aircraft to complete the shipment. This is an efficient way to transport cargo and relocate aircraft in the same movement, unfortunately several mistakes were made during the shipment of these weapons (Plante, 2010; Spencer et al., 2012).

There were 12 total missiles that were originally scheduled to ship from Minot AFB to Barksdale AFB. These missiles were intended to be loaded with nonnuclear Tactical Ferry Payloads (TFPs) instead of live payloads, such as nuclear warheads. The 5th Munitions Squadron was in charge of preparing the missiles for transport and they began by loading all of the missiles on two separate missile pylons, each holding 6 missiles. All of these missiles were meant to be loaded with TFPs before departure, but before departure the munitions control section changed which missiles were to be shipped, but did not communicate this to the nuclear weapons maintenance shop, who were responsible for preparing the TFPs. Because of this miscommunication, 6 missiles were prepared correctly and the other 6 were carrying nuclear warheads (Spencer et al., 2012).

At the time there was a shortage of storage space for these missiles, which meant that both nuclear and nonnuclear cruise missiles were often stored in the same location. Since the only way to identify the difference between a nuclear and a nonnuclear missile is by looking through a small observation window to check for the appropriate markings, proper protocol is to mark the missiles with a placard. Only one missile pylon had been marked with a placard stating "Ready for Tac Ferry". The other pylon had no placard, so the handling crew assumed that it

was the same as the other pylon rather than following the missile safe status check to ensure that both pylons were loaded with TFPs (Spencer et al., 2012).

When the missiles were brought to the aircraft, both the Radar Navigator and the Navigator are responsible for verifying the status of the missiles during preflight inspections of the aircraft when dealing with nuclear weapons. Unfortunately, only the Radar Navigator performed the preflight inspections. Also, when conducting the inspection, the Radar Navigator only checked one of the two pylons, which happened to be the nonnuclear pylon. He then made the assumption that the other pylon was correct and cut the preflight inspection short. "Doom 99" then made the trip from Minot to Barksdale and sat on the tarmac unguarded for 9 hours before the Barksdale handling crew came to transport the missiles to the storage facility. This crew conducted the inspection correctly and discovered the pylon of nuclear missiles and immediately alerted their leadership (Spencer et al., 2012).

Several specific errors in procedure had to take place to allow this mishap to occur. The first mistake was the not correctly labeling the pylon trailers. This was an individual mistake, but one that was probably influenced by the decision to store nuclear and nonnuclear missiles in the same location. The second error was a communication breakdown between the munitions personnel and the maintenance personnel. This was a scheduling error and resulted in an alternate set of missiles to be used for the transport (the missiles loaded with nuclear warheads). The third and fourth mistakes came when the munitions personnel did not oversee the movement of the weapons and the handling crew did not follow the checklist to ensure that the weapons were nonnuclear. The fifth error occurred on the flight line when the aircraft crew chief signed off on the weapons without confirming their status. The final error that took place was when the radar navigator on the aircraft did not follow his checklist and only inspected one of the two

pylons. These seven errors explain how these nuclear weapons were mistakenly shipped to Barksdale AFB (Norris et al., 2016; Spencer et al., 2012).

After the nuclear missile shipment incident occurred, the Air Force began tightening down on its nuclear program. Unfortunately, this is when it was revealed that Taiwan had received classified sections used on the Minuteman III intercontinental ballistic missile instead of helicopter batteries as it had ordered from the United States (Spencer et al., 2012).

The Air Force uses a supply system called Readiness Based Leveling to conduct service-wide adjustments to ensure that all locations have the correct inventory levels of items in their warehouses. This system in used semi-annually and in February of 2005, this system identified a requirement for 11 forward sections of the MK-12 reentry vehicles used on the Minuteman III intercontinental ballistic missiles (ICBM) at F.E. Warren AFB, Wyoming. The system showed that there was currently one of these forward sections at F.E. Warren AFB, so an automatic transaction to ship 10 units was completed. When the forward sections were delivered they were properly received and stored under a controlled-item status (Spencer et al., 2012).

After this shipment was completed, an inexperienced Air Force Item Manager at the 526th ICBM Systems Group at Hill AFB, Utah determined that F.E. Warren actually had too many MK-12 forward sections and directed the base to ship four of these forward sections to the Defense Logistics Agency (DLA) warehouse at Hill, AFB. After receiving this guidance, the F.E. Warren Traffic Management Office (TMO) packed the forward sections and prepared them for shipment. The F.E. Warren TMO placed the shipping documents inside the shipping container, but did not properly mark the exterior with the stock number as directed by the packaging instructions. Classified items like these are shipped with all documentation packed inside the container. Protocol requires the recipient to open the container, inspect the documents

and ensure that the contents of the container match the documents, sign a receipt and then send that receipt to the shipper. This process is used to ensure that the correct items are shipped and that the recipient verifies the delivery of the correct items (Spencer et al., 2012).

Unfortunately, the F.E. Warren TMO did not mark the outside of the shipping container which contained hazardous and classified cargo. When the shipping container arrived at the Hill AFB warehouse, the personnel did not open it, review its contents, sign a receipt, or return a receipt to F.E. Warren. F.E. Warren didn't even follow-up on the missing receipt as is required. Since the personnel at Hill AFB did not even open the shipping container they assumed that it was unclassified, nonhazardous material, so they stored it in an unclassified warehouse instead of the classified storage area. At a later date, DLA warehouse personnel tried to scan the barcode on the unopened shipping container in order to identify the contents. The scan was unsuccessful, so the warehouse personnel decided to use the hazard classification for the nomenclature and they arbitrarily selected a number that was for a helicopter battery. They marked the shipping container with this new identification and stored it in the warehouse labeled as helicopter batteries (Spencer et al., 2012).

The Air Force participates in the Foreign Military Sales Program where international partners have the opportunity to purchase certain items from the United States Government. This usually involves the sale of retired aircraft or aircraft parts that the United States no longer has a use for, but other countries may still use (Marion, 2013).

In 2005, the government of Taiwan requested 135 helicopter batteries through the use of the Foreign Military Sales Program. In 2006, the DLA warehouse at Hill AFB shipped the mismarked MK-12 forward sections as helicopter batteries. Taiwan identified the error in January of 2007 and an immediate investigation ensued (Spencer et al., 2012).

Similar to the shipment of the nuclear warheads, several different mistakes resulted in the unauthorized movement of these MK-12 forward sections. The first mistake was the incorrect marking of the shipping container by the F.E. Warren personnel. The second mistake occurred when upon arrival at Hill AFB the container was never opened and inspected. The third mistake was when the barcode could not be properly scanned and the warehouse personnel assumed what was inside the container rather than opening the container to properly identify its contents. The fourth mistake was that the personnel at F.E. Warren never followed up after never receiving the shipment receipt from Hill AFB. The final mistake was that the error was only confirmed by the United States government after several requests by the Taiwanese government to correct the shipment (Spencer et al., 2012).

These two incidents demonstrate the importance of following the correct shipment procedures for all DoD shipments. Mistakes like these can and will happen if precautions are not taken. Proper training and instruction for Traffic Management Offices, warehouse personnel, handling crews, and anyone who deals with shipments in any capacity is paramount to ensure accurate and timely delivery of supplies. Training will reduce shipping errors, but will not fully eliminate them. As long as the system is operated by humans, there will always be shipping errors. So if managers cannot eliminate these shipment errors, they can plan for them and work around them. If a manager has the ability to forecast and predict when and where errors will occur, they will be able to focus their efforts in that area in order to reduce the number of errors. If managers can identify a pattern in these errors this may help them identify the root cause of these mistakes and assist them in eliminating these faults all together.

Forecasting

Forecasting is an important tool that can be used to help predict future events. Though it is not quite an exact science, it depends on a set of statistical tools and techniques that are used in conjunction with human judgement and intuition. Hyndman and Athanasopoulos describe it as predicting the future as accurately as possible, given all of the information available, including historical data and knowledge of any future events that might impact the forecasts. Forecasting techniques can be applied in a wide range of fields including operations management, marketing, finance, risk management, economics, industry, and others. Although, certain events can be more accurately forecasted than others. For instance, the earth's weather patterns are predictable and can be forecasted with reasonable accuracy. In contrast, the winning numbers for the next Powerball drawing does not follow any sort of pattern and cannot be accurately predicted (Hyndman & Athanasopoulos, 2014).

In order to correctly predict an event there are certain factors that must be met. First, the researcher must understand all of the factors that contribute to the event. If there are certain variables that are not accounted for, the prediction will be inaccurate. Second, there needs to be an adequate amount of historical data. If there is little history to draw from, the forecast will rest heavily on human judgement rather than statistics based techniques. Third, the researcher must know whether the forecasts can affect the phenomenon that is being forecasted. This type of bias often occurs in the stock market. When sources advise that a stock will rise or fall, investors will buy or sell accordingly. This will cause the stock price to rise or fall and the forecast has effectively influenced the stock price (Hyndman & Athanasopoulos, 2014).

These factors help to determine whether or not an accurate forecast can be achieved. If one or more of these factors are not taken into account, the accuracy of the prediction will suffer.

Even when data are abundant, we may not fully understand all of the contributing variables, which will reduce the accuracy of the forecast. Each situation will vary with what information is available, what patterns can be observed, and what historical timeline is accessible. Sometimes there won't be any historical data at all, such as forecasting sales for a new product. These are all factors that must be taken into account (Hyndman & Athanasopoulos, 2014).

Forecasting is often used in business to help managers make decisions about inventory, scheduling orders, and aid in strategic planning. In order to effectively forecast, managers must establish goals which they want to achieve and develop a plan of how to achieve these goals. Goals should be developed with forecasts in mind to ensure that they are realistic. Likewise, plans should be developed in response to forecasts and goals. They will determine what actions need to be taken to meet these goals (Armstrong, 2001b).

Most organizations develop forecasts of different lengths to help achieve their goals. Short-term forecasts focus on the scheduling of production, inventory, employees, transportation, and distribution. These are the daily demand forecasts that help plant and warehouse managers stay on top of fluctuations. Medium-term forecasts are used to determine requirements in the near future. This includes hiring of personnel, ordering and shipment of raw materials, and purchasing of equipment. From a production perspective, this type of planning is done not only at the plant manager level, but also at the branch manager level. Finally, long-term forecasts are used in strategic planning for the firm as a whole. These forecasts take into account changes in the market, economic trends, possible opportunities for expansion, and even environmental factors (Armstrong, 2001b).

It is important for firms to develop multiple approaches to dealing with events. The combination of these different forecasts allows the firm to mold their plans to not only be

realistic, but also be accurate. The short-term models will have the most accuracy, but the others will provide insight on trends that the firm must be aware of (Armstrong, 2001a).

There are two different types of forecasting methods; qualitative and quantitative. Qualitative methods are based on human judgement, expert opinions and past experience. This type of forecasting is usually conducted when there is little to no data available, or if the available data does not assist in developing an accurate forecast. Quantitative forecasting can be used when there is applicable data available and there is reason to believe that there is somewhat of a pattern in the historical data that will continue. There are many different types of quantitative methods to choose from, all with differing specific purposes. Most either use time series data, which is collected at specific intervals over time, or cross-sectional data, which is collected at a single point in time. Although, before deciding on which method and model to use there are certain steps that must be taken (Hyndman & Athanasopoulos, 2014).

Forecasting usually involves five basic steps; defining the problem, gathering information, initial analysis, choosing and fitting models, using and evaluating a forecasting model. To begin, managers must identify the problem which they want to solve. This can be difficult because often the symptoms of a problem are observable, but the root cause remains undefined. Once the problem is correctly defined, managers will now have an understanding of the ways in which forecasts will be used, who needs them, and how they will benefit the organization (Armstrong, 2001b).

Gathering information is a crucial step which will help determine how accurate the forecast may be. Access to good, usable data allows researchers to develop extremely accurate predictions. Unfortunately, data are not always available. There may be times where no data were collected, or the particular variable that is needed is not available, or the data may not exist

at all. There are two types of data; statistical and judgmental. While both are useful, it is important to understand when to use each and how they work together. With quality data available, statistical models will provide accurate forecasts. However, there will not always be enough historical data to fit a good statistical model. This is when human judgment may be needed to make the best predictions. But what tends to happen the most is a combination of the two. Organizations will collect statistical data and conduct an analysis. This analysis will then be reported to the leadership of the organization, who will then use this information and their accumulated experience to make a decision (Hyndman & Athanasopoulos, 2014).

Once the data is collected an initial analysis can be conducted. The first step a researcher will likely take is to look at the data in different ways. They may graph it to get a visual representation. They will look for different trends or outliers. They will look for visible patterns or seasonality. They will also look for relationships to other variables that may be influencing the data (Bowerman, O'Connell, & Koehler, 2005).

Next the researcher will test different models and choose the best fit for the forecasted data. This will depend heavily on the available data, any relationships between the data and explanatory variables, and how the forecast will be used. Each model has a different set of assumptions that it uses to make predictions and by testing a few, some will prove more accurate than others (Bowerman et al., 2005).

Once the best model has been determined, it will then be used to make more forecasts. The model will have an associated confidence interval, but the true accuracy of the model will not be determined until the data for the forecast period becomes available. The organization can then reassess the model accuracy and ensure that it remains the best choice (Bowerman et al., 2005).

Both qualitative and quantitative forecasting methods exist. Qualitative forecasting uses human judgement and is very common in practice. There are many instances when judgmental forecasting is the only option due to a lack of historical data, or the data will not become available until later, but a decision must be made now. Qualitative forecasting can also be applied after statistical forecasts are generated. Managers will use the statistical findings and then use their subject matter experience to make a decision. Other times both statistical and judgmental forecasting are accomplished separately and then compared and combined. The accuracy of qualitative forecasting is higher when the forecaster has a high level of experience and knowledge in the field of study and when the forecaster is provided with current information. Obviously experience is important, but judgmental forecasting needs to adjust to changes in information and events as they take place. Although, in most cases, when data are available, this will be the starting point. When quantitative data are available, statistical forecasting will usually be preferred over judgmental forecasting (Hyndman & Athanasopoulos, 2014).

Quantitative forecasts can range from being as simple as a linear model of time series data to being as complex as an exponential smoothing model. Different types of data will require different techniques to make accurate forecasts. A simple linear model will not be able to account for seasonality in the data. Other, more complex models may require unnecessary work for data that follows a simple trend line. The researcher must use good judgment and test multiple models in order to find the best one (Bowerman et al., 2005).

Shipment Errors

This study deals with Air Force shipment errors and investigates the trends that can be identified in the hope to reduce and prevent them from taking place. In 2015 a similar study was

conducted on fulfillment errors at the distribution center of a major retailer (the name of the retailer was not disclosed to protect anonymity). The retailer is a 700-store retailer of apparel, electronics, and housewares (60% of its sales), as well as food items (40% of its sales). But even a large retailer such as this is burdened with shipping a distribution difficulties. The study found that 7% of all of the retailer purchase orders experience a fulfillment error. The most common types of errors include quantity shortages, ticket errors, and inaccurate advanced ship notices, a large majority of these are preventable and correctable at the distribution center level. The study estimated that these errors imposed a cost between 1% and 4% of the distribution center's operating budget. This percentage is low, but the cost of these errors is substantial and reducing them would be a tremendous benefit to the retailer. (Craig, Dehoratius, Jiang, & Klabjan, 2014)

These types of errors are affecting the container shipping industry as well. One of the biggest challenges for sea lift container shippers is maintaining a high rate of accurate invoices. Pressure to cut costs and reduce rates resulted in a reduction in carrier invoice accuracy as the amount of back-room staff decline. This shifts the burden of ensuring invoice accuracy onto the shippers. The shippers must now spend more time to inspect invoices and ensure that they correctly list what is in each container and where each container must go. Despite these efforts by the shippers it is estimated that over 15% of all ocean carrier invoices contain errors. The cost of these errors range from $50,000 to $150,000 per year for each individual shipper (Morley, 2016).

The trend that has led to this mismanagement of the shipping process is attributed not only to the pressure to reduce cost, but also the growing need to send out invoices quickly. In recent years the shipping rates have been unpredictable. This has influenced carriers and 3PLs to shift their focus from ensuring accurate invoices to getting shipments out quickly. The mistakes

are usually a combination of computer and human error, which ultimately would be reduced by more robust training (Morley, 2016).

This same pressure to get shipments delivered quickly is also experienced in the Air Force. Often there is a compromise in precision in order to get an item shipped on time. Air Force Transportation Officers are well trained and their teams operate at a high level, but there are instances when the "mission" requires these personnel to cut corners a bit to get a shipment out on time.

The Air Force is experiencing a deficit in personnel, which also affects the level of accuracy of these shipments. Most Air Force personnel currently have multiple responsibilities, which results in personnel spreading their focus between different tasks. A reduction in manpower increases the likelihood of these overworked individuals making a mistake or cutting corners.

Forecasting to Reduce Shipping Errors

Forecasting techniques are widely used among commercial organizations for many different areas. These techniques can be used to help determine customer demand, individual item sales, raw material usage, and even production plant throughput. In fact, forecasting plays such an important role in supply chain management that much of the success an organization experiences can be attributed to accurate forecasting. Alternatively, poor forecasting can prove to be disastrous for organizations. This fact stresses the importance of ensuring that the correct forecasting techniques are used for the right situations.

Managers are always working to optimize their supply chains from raw material collection, to the manufacturing and distribution centers, all the way to the customer.

Forecasting is a tool that is used to improve this process. When management applies forecasting techniques it is usually done on an enterprise level, but this may not always be the best approach. For organizations to have the most accurate information they must conduct forecasts at different levels of the process. There are three different approaches to forecasting that are currently used in commercial ERPs; aggregate, profile, and microforecasting (Arminger, 2003).

Aggregate forecasting takes a broad approach and observes the organization as a whole. It uses inventory information and reduces complexity by ignoring the interactions between parts of the supply chain, but rather looks at the supply chain as a whole. By doing this, managers are able to create a single forecast for each item across the entire supply chain. The issue with a forecast designed like this is that the forecast never studies any specific item or functional area. This means that managers will not be able to determine the individual needs of functional areas along the supply chain, or the reasons why inventory fluctuations are taking place. This technique is best used to observe general trends, but should not be used to answer specific questions about individual items or supply chain sections (Arminger, 2003).

Profile forecasting observe the throughput of individual functional areas and individual items as they pass through these areas. This technique is characterized by its ability to apply seasonality to the forecast. Since the scope has narrowed down to the functional area level, historical trends about each particular section can be studied and if patterns emerge this can be used to predict future levels. Unfortunately, in large organizations that have multiple production plants there may be multiple variations of the same functional area. This will add variability to the forecast because there may be different issues that are dealt with at each location (Arminger, 2003).

Microforecasting creates a single forecast for each individual item as it passes through each functional area and the supply chain as a whole. The specificity of this forecast allows for trend and seasonality from historical data to be utilized. This technique provides an accurate forecast due to the fact that no information has been combined and each item and section is observed separately. Because of this, managers are provided with up to date and accurate forecast data for each item passing through the supply chain. Though this method is very beneficial, it can prove to be difficult to maintain. It requires constant database updates to ensure forecasts are current. If this is to be done by employees it will reduce productivity in other areas. The best solution is to automate the process if possible (Arminger, 2003).

These techniques are not solely applicable to products passing through a supply chain, but can also be applied to the errors within that supply chain. Just like the products themselves, the errors that they manifest can be observable, recordable, and predictable. This means that managers have the ability to apply forecasting techniques when studying these errors. When using each of the previously mentioned forecasting methods, managers will obtain information at different levels of the supply chain. If a manager conducted an aggregate forecast on shipping errors it would produce a broad forecast that showed the total number of errors across the entire company. This is a good place to start and can be used as a benchmark for future improvements, but a more detailed approach will be necessary to begin making corrections.

The profile method will help identify the specific offices that are producing the most shipping errors. This will allow management to focus their efforts on the areas that require improvement. But this method does not demonstrate why the errors are happening in the first place, it only gives the manager an idea of where they are coming from. In order for leadership to make significant progress on reducing these errors they will need to conduct a microforecast

of each item or each discrepancy type. This will provide valuable information on what specifically is being shipped incorrectly and what specifically is being done incorrectly. The combination of these three techniques gives management an overview of all shipping errors within the organization, a list of the offices at fault, and a list of items and discrepancy types that are most common with these mistakes. Having this information allows leadership to make specific corrections to these critical areas efficiently and effectively.

III. Methodology

Overview

This chapter provides details on the data used in the study, how the data was collected and compiled, and also the methodology used to analyze the data.

Data Collection

In order to conduct a proper analysis of a problem, the first and most important step is to have good, usable data. If data are not available, or not complete, the results of the analysis will be weak due to this deficiency. Due to this fact, special care was taken to accurately record data from a DoD web database to ensure the utmost precision.

The data used for this study were pulled from a Defense Logistics Agency (DLA) Transaction Services web database call "WebSDR" or Web Supply Discrepancy Reporting. This database tracks all shipment discrepancies recorded by every branch of service in the DoD. The amount of information stored in the website is vast, ranging from individual discrepancy details to numbers of discrepancies per time period and location. Data is stored as far back as 2006, which gives researchers an abundant amount of data history to use for analysis.

Since the database contains a large amount of information, the scope of the research needed to be narrowed down. As stated above there are many different types of information available to observe, but to best serve this study, specific supply discrepancy code totals were recorded in monthly increments.

This meant focusing on a small number of specific variables (discrepancy codes). In order to determine which discrepancy codes to study, historical data were pulled for the past three years. The top five most common discrepancies from this time period were used for the study. These discrepancies are Documentation Not Received, Documentation Incomplete/Improper, Returned PDQR Exhibit Deficiency, Distribution Center Receipt Not Due-In, and Electrostatic/Electromagnetic Device Preservation Inadequate or Omitted which are denoted by D1, D3, Q11, Z3, and P113 respectively. In addition to these discrepancies, the Air Force Installation Mission Support Center requested a focus on discrepancies that specifically pertained to packaging errors. Thus, a similar effort was conducted where the top five most common packaging discrepancies recorded over the last three years were selected to be studied. These discrepancies are Electrostatic/Electromagnetic Device Preservation Inadequate or Omitted, Container Inadequate/Incorrect/Oversized, Level of Protection Excessive or Inadequate, Non-Conformance to Specified Requirements for Packing, and Labels Omitted or Improperly Affixed which are denoted by P113, P201, P206, P210, and P303 respectively. All of these discrepancies totaled to 9 because one of the overall top discrepancies was also a top packaging discrepancy code.

Once all of the discrepancy codes were selected, the data collection could begin. Historical data were pulled for monthly increments. From these data pulls the total number of discrepancies and total cost of the discrepancies were recorded per discrepancy code. Data were collected in this fashion until 5 years of data were collected for each discrepancy code.

Tools

The statistical tools used to collect and analyze the data in this study were MS Excel and SAS's JMP. These are both widely used statistical computing software that are commonly used in forecast analysis.

Methodology Used to Address the Research Questions

This section describes the methods and procedures used to address the formulated research questions.

In order to narrow the scope of this research and determine the most important variables to study, the data collection process described above was conducted. These five discrepancies proved to be the most costly to the Air Force and they, in addition to the requested codes by AFIMSC, will be the focus of this research.

1. *How can the Air Force better forecast SDRs?*

Forecasting is important for warehousing and supply chain management, but it is not usually used to project errors in the supply chain. To conduct this analysis, an array of different forecasting methods were implemented. The following is a listing and description of the different methods.

Time Series Regression

Time series regression is a forecasting method that uses historical data in order to make predictions. A simple regression model uses data and fits a straight line to it. This model is defined by the following equation:

$$Y = \beta_0 + \beta_1 X + \varepsilon \quad (1)$$

In this equation the Y represents the dependent variable and X represents the independent variables. β_0 and β_1 represent the intercept and slope of the line respectively. β_0 determines the predicted value of Y when X = 0. Since the data does not fall in a straight line, each observed data point contains random "error", ε. This does not imply a mistake, but rather a deviation from the linear model.

Decomposition

When time series data does not follow a simple linear model it may exhibit many different patterns. Depending on the different type of pattern that the data follows, there may be a particular model that will best match that pattern. Decomposition considers some of these patterns and methods to extract the associated components from a time series. For this research two decomposition methods were used; multiplicative and additive. These methods each have three components: trend, seasonal, and cyclical. The following is a description of each component and how they affect the behavior of the time series.

Trend

Time series follow a trend when there is a long-term increase or decrease in the data. This trend does not necessarily need to be linear, but must be generally positive or negative.

When the pattern of data changes from positive to negative, or vice versa, it is considered to be "changing direction".

Seasonal

A seasonal time series pattern is determined by seasonal factors, such as day of the week, monthly, or season. Certain products follow a seasonal demand pattern, for example flower sales spike around Valentine's Day and Mother's Day. Flower companies will typically sell more flowers in the weeks prior to these holidays than they do during other times of the year.

Cyclical

Data follow a cyclical model when there is a pattern that that is not a simple trend, but also does not fall within a fixed period. This data pattern has peaks and troughs, but they are not associated with a time of year or a seasonality component. Usually these patterns are over two years long.

Additive

The additive model is expressed as the following formula:

$$Y_t = T_t + S_t + E_t \qquad (2)$$

Y_t represents the data at period *t*, S_t is the seasonal component, T_t is the trend-cycle component, and E_t is the remainder (error) component at period *t*. This model is most appropriate if the magnitude of the seasonal fluctuations does not vary with the level of the time series.

Multiplicative

The multiplicative model is expressed as the following formula:

$$Y_t = T_t \times S_t \times E_t \quad (3)$$

The multiplicative model uses the same components as the additive model above. It is most appropriate when the variation in the seasonal pattern is proportional to the level of the time series.

Exponential Smoothing

Exponential smoothing is a type of forecasting model that uses weighted averages of historical data, with the weights decaying exponentially as the observations get older. Essentially, the more recent observations will be weighted higher when making predictions.

Simple

Simple exponential smoothing is most accurate for data that has neither a trend nor seasonal pattern, but does change over time. The equation of the simple exponential smoothing method is as follows:

$$l_T = \alpha y_T + (1 - \alpha) l_{T-1} \quad (4)$$

The current prediction is represented by l_T, the smoothing constant is α, the current observation is y_T, and the previous prediction is represented by l_{T-1}.

Holt's Trend

The Holt linear trend method was created to forecast time series that follows some sort of a trend. This method introduces a term into the equation to determine the effect of this variable on the trend. The equation for the Holt trend is shown in Equation 5:

$$l_T = \alpha y_T + (1 - \alpha)[l_{T-1} + b_{T-1}] \quad (5)$$

The components of the Holt's Trend model are as follows; the current prediction is l_T, the current growth prediction is b_T, the smoothing constant is α, the smoothing growth constant is y, the last observation is y_T, the previous prediction is l_{T-1}, and the previous growth prediction is b_{T-1}. The initial l_0 is the intercept of the regression on the first half of the data, and the initial b_0 is the slope of the regression on the first half of the data.

Holt-Winters

The Holt's trend method can be modified to forecast data with both trend and seasonal components. These different two data components have two different specific models. The Additive Holt-Winter method is used to forecast constant seasonal variation and the Multiplicative Holt-Winter Method is used to forecast increasing seasonal variation data sets. The Holt-Winter method equations are as follows:

Additive Holt-Winters:

$$Y_t = (\beta_0 + \beta_1 t) + SN_t + \varepsilon_t \quad (6)$$

Multiplicative Holt-Winters:

$$Y_t = (\beta_0 + \beta_1 t) \times SN_t \times IR_t \quad (7)$$

In regards to the components of the above Holt-Winters models, the value of the time series in period t is represented by Y_t, $(\beta_0 + \beta_{1t})$ is the trend component, SN_t is the seasonal component for time period t, IR_t is the irregular component in time period t, and ε_t is the error component in time period t.

Box Jenkins

The Box-Jenkins method refers to the autoregressive moving average (ARMA) forecasting model. This model's intended use is to describe the autocorrelations in the data. But before this can be done there are certain requirements that need to be met to ensure an accurate forecast. First, it must be determined whether the data is stationary or seasonal in any way. A stationary data set is one whose properties do not depend on the time at which the series is observed. Essentially, what this means is that to use the Box Jenkins model the data must not have a trend or seasonality. This is best observed using Time Series Diagnostics in JMP. The Sample Autocorrelation Function (SAC) and Sample Partial Autocorrelation Function (SPAC) will exhibit certain behaviors that the researcher will be able to identify as either stationary or nonstationary. When the SAC dies down slowly the data is nonstationary, but when the SAC dies down quickly the data is stationary.

Differencing is a tool that can be used to make a time series stationary. It computes the differences between consecutive observations. This is known as an ARIMA model, adding an "I" for "Integrated".

Choosing the Methods

Each one of the forecasting techniques listed above were implemented for each of the nine variables in the study. The next step in the process was to determine which method performed the best for each of the individual variables. Five different parameters (discussed in the following section) were chosen to judge the accuracy of each forecast. For each variable tested a table was created that displayed each model and their corresponding parameter results. This table was used to determine the best forecasting technique for each variable.

Validity Assumptions

Once the different forecasting models were created it was crucial to determine whether or not they could be used in the study. This means that the model must meet all of the validity requirements, including normality, independence, and constant variance.

2. *How can the Air Force assess the validity of these forecasts?*

In order to measure the results of these tests, five different parameters were used to compare them: the Sum of Squared Errors (SSE), the coefficient of determination (R^2), the Mean Absolute Percentage Error (MAPE), the Relative Absolute Error (RAE), and the Theil's U-statistic (Theil's U). The following are descriptions of the parameters used.

Parameters

Sum of Squared Errors

The sum of squared errors (SSE) is calculated by squaring each error term and summing them. This is a good tool to compare between different tests. The model with the lowest SSE contains the lowest amount of error. The formula is as follows:

$$SSE = \sum (y_i - \hat{y_i})^2 \tag{8}$$

Coefficient of determination

The coefficient of determination (R^2) is a figure that represents the accuracy of a forecast, specifically how well the data fit the statistical model being used. The value of R^2 should fall between 0 and 1, which allows the researcher an easy tool to compare with other models. A score of 0 means that the model does not fit the data at all, while a score of 1 means that the

model is a perfect fit for the data. The coefficient of determination is achieved by dividing the explained variation in data by the total variation.

The formula for explained variation is as follows:

$$\text{Explained Variation} = \sum(\hat{y}_i - \bar{y})^2 \tag{9}$$

The formula for total variation is as follows:

$$\text{Total Variation} = \sum(y_i - \bar{y})^2 \tag{10}$$

The coefficient of determination (R^2) is calculated by dividing the explained variation by the total variation.

$$R^2 = \frac{\sum(\hat{y}_i - \bar{y})^2}{\sum(y_i - \bar{y})^2} \tag{11}$$

Mean Absolute Percentage Error

The Mean Absolute Percentage Error (MAPE) is a tool that provides a value for the percentage of error in a forecasting model. The higher the value of the MAPE, the more inaccurate the forecast is, and vice versa. Therefore, low MAPE scores are best.

$$\text{MAPE} = \left(\frac{1}{n}\sum\frac{|\text{Actual}-\text{Forecast}|}{|\text{Actual}|}\right) * 100 \tag{12}$$

Relative Absolute Error

The Relative Absolute Error (RAE) is a tool that is used to compare the accuracy of a model against the accuracy of a naïve forecast (which simply uses the value from each previous period as the forecast). RAE is calculated by dividing the forecast error percentage (MAPE) of the model by the forecast error of the naïve model. The value provided can give the researcher a great deal of information. Obviously a low value is preferable, as the lower the value is the less errors exist in the model. But also what this metric shows the researcher is how the model compares to a very primitive model where the forecast for the next period is simply the number of the current period. If the value is below 1 then the model is better than the naïve model. If the value equals 1 then there is no difference in accuracy between the models. And if the value is greater than 1 the naïve model is actually more accurate than the current model being tested.

The formula for RAE is listed below:

$$RAE = \frac{actual\ forecast\ error}{naive\ forecast\ error} \tag{13}$$

Theil's U-statistic

The Theil's U-statistic takes a similar approach as the RAE does in which it compares the error of the current model to the error found in the naïve model. Instead of using the MAPEs to compare error, it squares the errors to eliminate negative values, then divides the sum of the errors in the current forecast by the errors found in the naïve forecast. The square root of this value provides the researcher with the Theil's U-statistic. This test is evaluated the same way that the RAE is judged. If the Theil's U of the current model is less than 1 it is more accurate

than the naïve forecast. If it equals 1 then it is as good as the naïve model. But if it is greater than 1 the naïve model is better than the forecast technique being tested.

The formula for the Theil's U-statistic is listed below:

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} \left(\frac{\hat{y}_{t+1} - y_{t+1}}{y_t}\right)^2}{\sum_{t=1}^{n-1} \left(\frac{y_{t+1} - y_t}{y_t}\right)^2}} \tag{14}$$

Comparison

All five of these parameters listed were calculated for an estimation period as well as a validation period. The estimation period includes the first four years of historical data, which are used to create the forecast. The validation period observes the last year of data and acts as a test to compare the forecast of each model to the actual data of the fifth year. This provides the researcher an accurate evaluation of each model in addition to the parameters used in the estimation period.

Once all models were completed a chart was created for each variable to compare all models and parameters. These charts list the parameter values for both the estimation and validation periods. This allows for easy analysis of the quality of the models used. The researcher can observe which models performed the best for each specific variable. Based off of these charts the top model was chosen for each variable. These models will be used to forecast their respective discrepancy codes in the future.

IV. Results and Analysis

Overview

This chapter discusses the results of the study and includes a detailed analysis of the models used in Chapter III.

Forecasting Methods

The data observed in this research were studied using 25 different forecasting models. This approach allowed for various types of models to be tested, ranging from simplistic to complex. The reason for such an approach is because conducting many different forecasts on the same set of data creates more options and can result in a more accurate forecast than simply running one or two different models. It is important to note that both simple and complex forecasts can be appropriate given the right set of data. By conducting many different tests, the researcher ensured that the correct forecast was selected for each variable.

Five years of data were collected in monthly increments for each variable. This resulted in 60 monthly data points for each variable. The data was then split into two groups; the forecast estimation group and the forecast validation group. The estimation group consisted of the first 48 months of data where the forecasting techniques were initially implemented. The validation group made up the final year of the data, in which the techniques used in the estimation portion were implemented without the use of the actual data. This was done to test the validity of the forecast against the actual data.

Following the completion of the forecasting models, a chart was built for each variable which listed each forecasting model and the performance of each model based on the five

different parameters (SSE, MAPE, R^2, RAE, and Theil's U). The charts were designed to highlight the top five values for each parameter. This allowed the researcher to determine which methods work best for each variable based on the highlighted values. An example of this chart is demonstrated in Table 1 below.

Table 1. Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	5,421,172.5266	0.4596	165.8844	5.5622	5.2868	36,457,180.0618	0.0797	57.9102	3.4249	3.5034
Trend	462,239.4130	0.9539	35.0332	1.1747	1.2339	144,910,008.9131	N/A	60.5547	3.5813	3.5010
Dummy	1,638,451.3831	0.8367	107.3059	3.5980	3.7567	5,009,516.3154	0.7704	16.5865	0.9810	1.2674
Trigonometric L=1	1,701,664.2321	0.8304	108.7011	3.6448	3.5671	5,018,256.1290	0.7415	16.8574	0.9970	1.2643
Trigonometric L=2	1,121,888.6645	0.8882	77.9661	2.6143	2.2256	9,494,917.8896	N/A	25.6625	1.5177	1.7407
Trigonometric L=3	278,627.5021	0.9722	29.6533	0.9943	0.8766	2,706,582.8697	0.3361	17.9344	1.0607	1.0196
Trigonometric L=4	251,743.3245	0.9749	27.6350	0.9266	0.7961	5,685,630.8389	0.3029	21.4389	1.2679	1.2936
Autocorrelation L=1	541,515.2038	0.8743	40.3534	1.3531	1.1067	3,453,317.8472	0.8075	19.1992	1.1355	1.1198
Autocorrelation L=2	505,024.2823	0.8872	35.5732	1.1928	1.0437	4,768,858.8534	0.8052	21.1255	1.2494	1.3001
Autocorrelation L=3	326,338.1582	0.9738	31.7938	1.0661	0.9741	2,143,940.9441	0.4742	16.2980	0.9639	0.8240
Autocorrelation L=4	343,422.0280	0.9783	29.7906	0.9989	0.9075	5,972,597.1919	N/A	24.4845	1.4480	1.3617
Decomp Multiplicative (12)	212,131.5779	0.9878	20.6478	0.6923	0.7200	1,068,990.2318	0.9380	7.8121	0.4620	0.7200
Decomp Multiplicative (4)	674,193.4078	N/A	31.0890	1.0424	1.5605	534,231.7622	0.9727	5.7305	0.3389	0.4400
Decomp Additive (12)	207,209.2076	0.9548	25.5365	0.8563	0.7512	1,608,508.3620	0.8730	8.8003	0.5205	0.6979
Simple Exponential Smoothing	720,601.0715	0.8450	30.6729	1.0285	0.9763	16,114,692.0366	N/A	33.7657	1.9970	2.1204
Holt's Trend	513,020.7697	N/A	32.9172	1.1037	1.0054	4,185,391.7677	0.3218	17.3359	1.0253	1.1056
Additive Holt-Winters (4)	5,404,629.5737	0.4645	165.3418	5.5440	5.3656	36,445,051.5380	N/A	57.9509	3.4273	3.5017
Additive Holt-Winters (12)	649,727.3272	N/A	60.1586	2.0172	1.3714	2,651,765.7795	0.4195	14.1146	0.8348	0.8887
Multiplicative Holt-Winters (4)	18,349,716.4620	N/A	158.1725	5.3036	1.8816	168,814,663.4150	N/A	163.8434	9.6899	9.2869
Multiplicative Holt-Winters (12)	1,458,722.9186	N/A	64.7282	2.1704	1.9967	41,598,152.8490	N/A	70.0972	4.1457	4.0660
ARIMA (0, 0, 3 - 4)	3,407,531.8500	0.9363	60.2931	2.0217		3,407,531.8500	0.9363	60.2931	2.0217	
ARIMA (0, 0, 3 - 12)	6,529,779.3800	0.8767	102.4760	3.4361		6,529,779.3800	0.8767	102.4760	3.4361	
ARIMA (3, 0, 3 - 4)	157,663,068.0000	0.0000	338.7440	11.3583		157,663,068.0000	N/A	338.7440	11.3583	
ARIMA (3, 0, 3 - 12)	2,084,765.0500	0.9277	61.8048	2.0724		2,084,765.0500	0.9277	61.8048	2.0724	

Practical Application of the Forecasting Techniques

Once the analysis of each variable had been completed, and each comparison chart had been constructed, the most accurate forecasts could now be identified. There were 9 different discrepancy codes that were observed in this study. The following is an analysis of each code:

D1 (Documentation Not Received)

The resulting comparison chart for this item is depicted in Table 2 below.

Table 2. D1 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	189,289.1174	0.1318	36.1586	1.3787	1.1346	939,307.2735	0.0517	57.7764	2.2638	2.0815
Trend	189,254.4541	0.1319	36.1549	1.3785	1.1345	939,747.6275	0.0518	57.7980	2.2646	2.0820
Dummy	58,995.8169	0.7294	17.8765	0.6816	0.6432	209,834.6102	0.3952	20.8977	0.8188	1.0267
Trigonometric L=1	75,040.7768	0.6558	19.8035	0.7551	0.6864	224,040.5454	0.3863	21.3867	0.8380	1.0470
Trigonometric L=2	76,829.9388	0.6476	18.6593	0.7115	0.6468	204,099.1323	0.4364	20.5221	0.8041	1.0016
Trigonometric L=3	76,426.9582	0.6494	20.1866	0.7697	0.6299	415,744.6016	0.0661	30.3768	1.1902	1.3523
Trigonometric L=4	79,413.5635	0.6358	20.2891	0.7736	0.6648	219,823.5994	0.4004	22.4877	0.8811	0.9907
Autocorrelation L=1	81,346.0491	0.5559	21.2858	0.8116	0.7019	208,504.9210	0.3862	20.7067	0.8113	0.9918
Autocorrelation L=2	79,034.3647	0.5671	20.1541	0.7684	0.6514	232,436.1743	0.4215	22.9779	0.9003	1.0377
Autocorrelation L=3	79,978.8947	0.6037	20.9533	0.7989	0.6854	449,224.4892	0.0556	31.2644	1.2250	1.3713
Autocorrelation L=4	80,556.5543	0.6070	21.1246	0.8055	0.6923	579,616.6604	0.0179	38.3846	1.5040	1.5553
Decomp Multiplicative (12)	42,088.3790	0.8814	12.3912	0.4725	0.4310	81,970.2469	0.8473	16.3151	0.6393	0.8183
Decomp Multiplicative (4)	38,962.4213	0.8363	12.6377	0.4819	0.4359	68,207.2992	N/A	14.3359	0.5617	0.7826
Decomp Additive (12)	36,131.5635	0.8143	12.0207	0.4583	0.4241	80,984.2301	0.8278	14.9159	0.5844	0.7914
Simple Exponential Smoothing	125,772.0942	0.6424	25.9237	0.9884	0.8221	236,293.0814	0.6345	24.8429	0.9734	1.0506
Holt's Trend	117,915.1581	0.8587	25.3340	0.9660	0.8562	269,638.3845	0.7843	29.1268	1.1412	1.0280
Additive Holt-Winters (4)	117,624.2800	0.6983	23.7065	0.9039	0.7807	597,492.0930	N/A	40.0989	1.5711	1.5494
Additive Holt-Winters (12)	86,595.5832	0.8146	20.3944	0.7776	0.7406	573,833.3232	N/A	39.0315	1.5293	1.5810
Multiplicative Holt-Winters (4)	122,134.5836	0.7222	23.9160	0.9119	0.7937	612,398.6334	N/A	40.6375	1.5922	1.5749
Multiplicative Holt-Winters (12)	156,644.3461	N/A	27.9611	1.0661	0.8824	666,403.5066	N/A	43.2560	1.6948	1.6641
ARIMA (0, 0, 3 - 4)	574,046.8540	0.2713	33.9182	1.2933		574,046.8540	0.2713	33.9182	1.2933	
ARIMA (0, 0, 3 - 12)	504,380.8240	0.2105	40.5272	1.5452		504,380.8240	0.2105	40.5272	1.5452	
ARIMA (3, 0, 3 - 4)	336,151.6660	0.4660	33.6746	1.2840		336,151.6660	0.4660	33.6746	1.2840	
ARIMA (3, 0, 3 - 12)	558,665.7900	0.0444	47.1462	1.7976		558,665.7900	0.0444	47.1462	1.7976	

From Table 2 it is clear that the models which most accurately forecasted the data were the three different decomposition models. Next, the researcher needed to determine which of the

three performed the best. Between the three different models both the Multiplicative (4) and the Additive (12) models performed well, each scoring highest on four different parameters. This tie breaker was decided by the fact that the Multiplicative (4) model had a poor R^2 value in the validation group, which meant that the best model for this discrepancy code is the Decomposition Additive (12) model. In reality there is very little statistical difference between these models and each would produce a similar forecast, but for the sake of the study the additive model is the best option.

To ensure that the model passes all validity standards, normality, constant variance, and independence assumptions must be met. A plot of the residuals shows that besides two outliers, the data is fairly linear and the variance is constant throughout. By excluding these two data points, the model becomes normally distributed and passes all other validity assumptions. Figure 1 is a plot of the residuals, a histogram of the residuals after removing the outliers, and the resulting Shapiro-Wilk W Test.

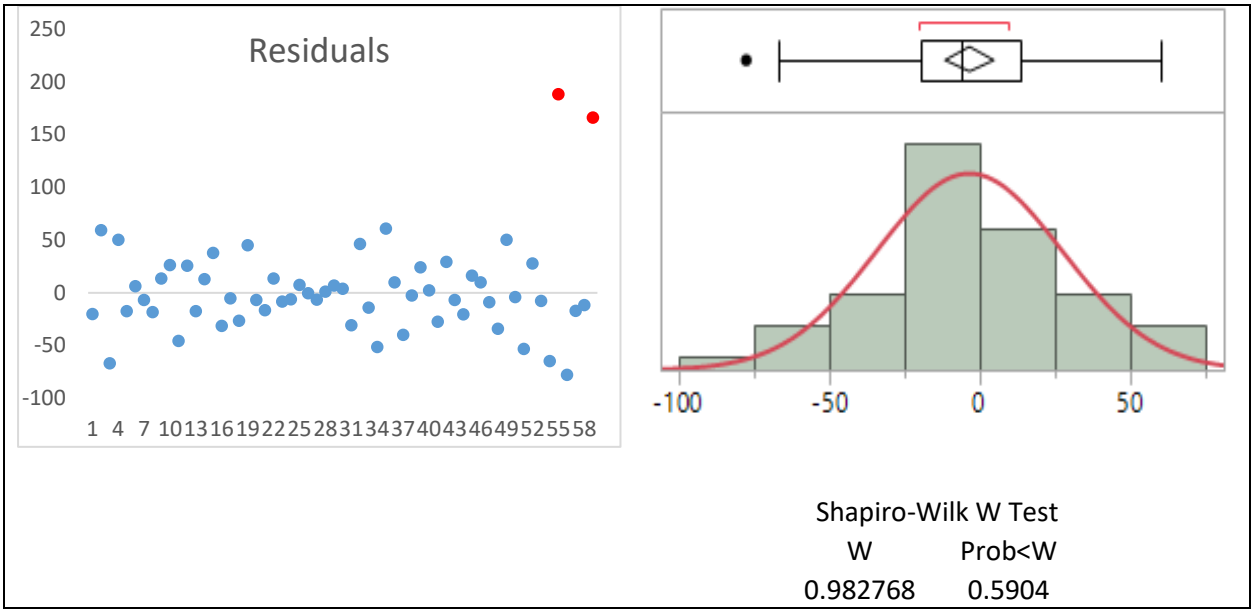

Figure 1. D1 Validity Assumptions

Figure 2 is a graphical representation of the discrepancy code data over the past five years along with the forecasted values. The forecast is very accurate during the estimation phase and maintains good accuracy during the validation phase despite an uncharacteristic spike in discrepancies during this phase.

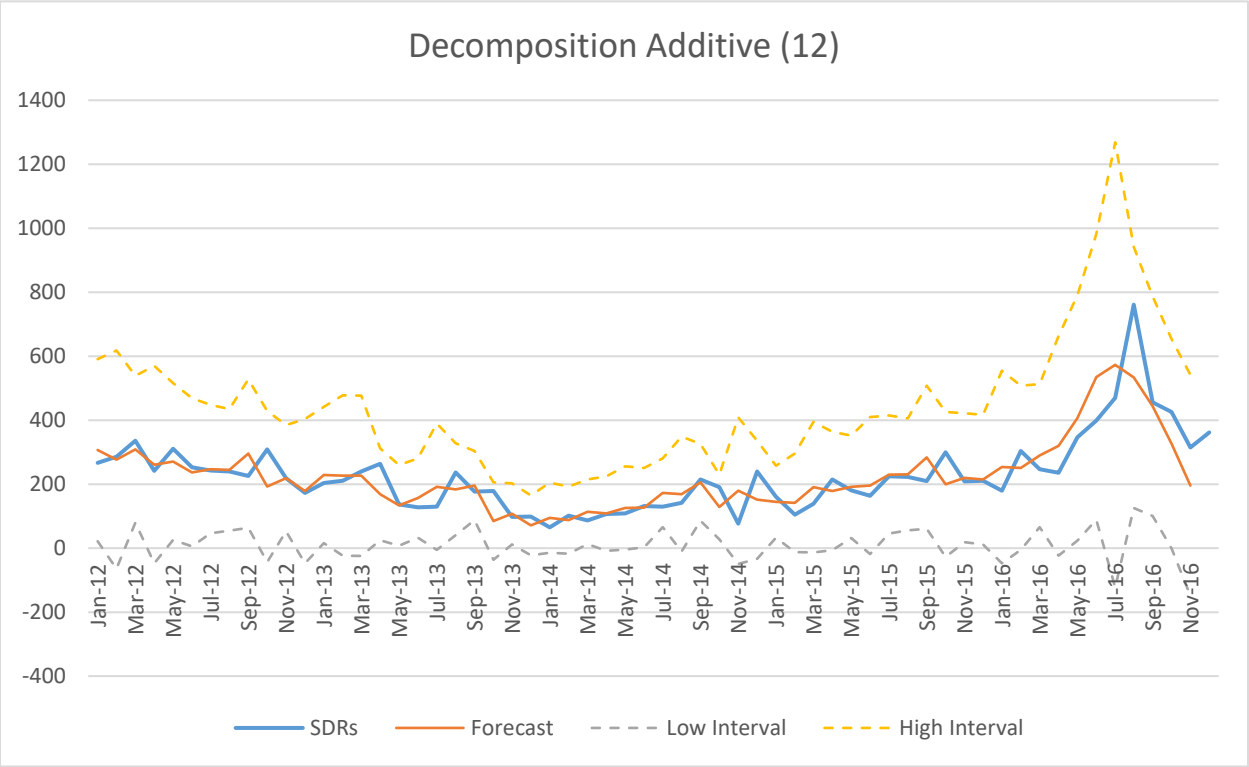

Figure 2. D1 Forecast

D3 (Documentation Incomplete/Improper)

The resulting comparison chart for this item is depicted in Table 3.

Table 3. D3 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	1,444,284.1702	0.1584	42.8699	1.5566	1.1954	619,945.7096	0.2785	28.3736	1.1790	1.2091
Trend	688,058.9425	0.5990	28.1089	1.0207	0.8701	299,771.1820	0.5406	22.3659	0.9294	1.0150
Dummy	593,043.7839	0.6544	29.7842	1.0815	0.9392	3,420,210.4640	N/A	95.0777	3.9507	4.4933
Trigonometric L=1	630,073.0835	0.6328	29.8539	1.0840	0.9285	3,416,793.1388	N/A	95.1562	3.9540	4.4410
Trigonometric L=2	738,036.6583	0.5699	30.6221	1.1119	0.9724	3,696,659.6449	N/A	98.5800	4.0962	4.7218
Trigonometric L=3	703,905.0536	0.5898	28.6651	1.0409	0.8892	910,419.4974	0.6110	47.0750	1.9561	2.5837
Trigonometric L=4	596,921.6633	0.6521	25.7815	0.9362	0.8353	13,766,610.0973	N/A	179.4568	7.4569	8.8404
Autocorrelation L=1	545,371.4660	0.6466	22.9566	0.8336	0.8000	1,969,914.9452	N/A	72.4872	3.0120	3.4093
Autocorrelation L=2	570,562.8389	0.6245	23.9246	0.8687	0.7935	1,920,161.1891	N/A	71.1051	2.9546	3.3800
Autocorrelation L=3	570,716.3920	0.6563	23.4501	0.8515	0.7767	775,355.2846	0.7148	43.9617	1.8267	2.2796
Autocorrelation L=4	565,473.8028	0.6701	23.4406	0.8512	0.7699	440,186.2469	0.4000	31.3903	1.3043	1.8100
Decomp Multiplicative (12)	183,098.3672	0.8405	12.9074	0.4687	0.4817	257,331.2901	0.7498	17.7042	0.7357	0.4817
Decomp Multiplicative (4)	167,687.0607	0.8381	12.6203	0.4583	0.4686	65,929.7650	0.6497	11.2873	0.4690	1.4097
Decomp Additive (12)	177,138.9787	0.8096	13.6296	0.4949	0.5370	241,793.0590	0.7061	17.9719	0.7468	1.9386
Simple Exponential Smoothing	919,426.6669	0.9537	30.8244	1.1193	0.9988	685,350.9098	0.4299	40.7897	1.6949	1.8811
Holt's Trend	983,081.0150	0.9241	32.7921	1.1907	1.0280	464,204.8594	0.1819	32.2477	1.3400	1.4712
Additive Holt-Winters (4)	858,070.0324	0.9407	29.0369	1.0544	0.9902	804,257.9708	0.5495	45.0624	1.8725	2.1018
Additive Holt-Winters (12)	681,296.1522	0.9640	27.3064	0.9915	0.8828	1,151,942.1693	N/A	54.4857	2.2640	2.3662
Multiplicative Holt-Winters (4)	856,733.4952	0.9454	28.9706	1.0519	0.9738	734,686.2128	0.3889	42.4582	1.7642	1.9430
Multiplicative Holt-Winters (12)	746,813.9188	0.6782	27.6301	1.0033	0.9991	776,113.8058	0.5905	43.7658	1.8186	2.0142
ARIMA (0, 0, 3 - 4)	2,043,837.4400	0.2313	45.4649	1.6509		2,043,837.4400	0.2313	45.4649	1.6509	
ARIMA (0, 0, 3 - 12)	1,590,665.8400	0.2034	49.9527	1.8138		1,590,665.8400	0.2034	49.9527	1.8138	
ARIMA (3, 0, 3 - 4)	2,051,412.9800	0.1782	40.3852	1.4664		2,051,412.9800	0.1782	40.3852	1.4664	
ARIMA (3, 0, 3 - 12)	1,304,730.7700	0.2102	50.5650	1.8361		1,304,730.7700	0.2102	50.5650	1.8361	

Similar to the D1 forecasts, D3 is dominated by the decomposition models in both the estimation and validation groups. But unlike the previous decomposition forecasts, the clear winner between the three models is the Multiplicative (4). Once again, these models are very similar and are close in most parameters, but the Multiplicative (4) edges out the other two models in nearly every category.

Regarding the validity assumptions of this model, this discrepancy code displayed no problems with linearity or homoscedasticity as there are no discernable trends in the residuals.

All validity assumptions are met without the need of a transformation or removal of outliers. Figure 3 displays the residual plot, residual histogram, and Shapiro-Wilk W Test result.

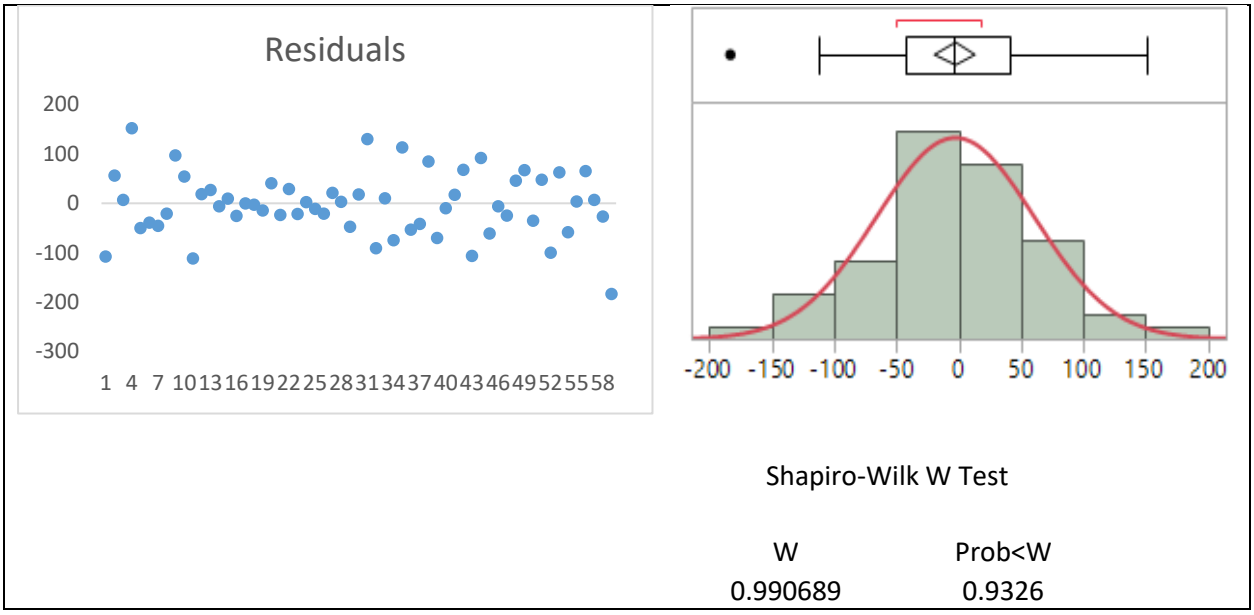

Figure 3. D3 Validity Assumptions

Figure 4 depicts all D3 discrepancy codes over the last five years along with the selected forecast. The decomposition model follows the trend of the data well and does so throughout the validation phase.

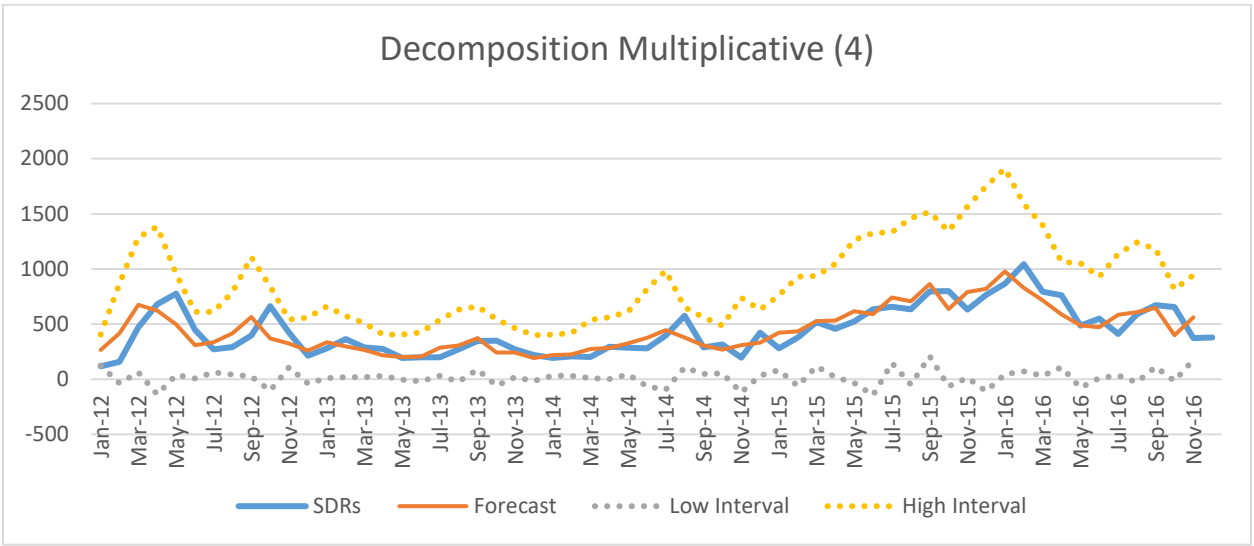

Figure 4. D3 Forecast

Q11 (Returned PDQR Exhibit Deficiency)

The resulting comparison chart for this item is depicted in Table 4.

Table 4. Q11 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	278,332.6477	0.2513	13.3540	0.7978	0.7850	226,925.3045	0.9321	19.5239	0.6949	0.8936
Trend	220,770.4485	0.4061	12.5077	0.7472	0.6885	383,175.7443	N/A	25.4264	0.9050	1.1168
Dummy	88,189.7195	0.7628	7.2751	0.4346	0.4710	150,135.4218	0.4916	23.3595	0.8314	0.9819
Trigonometric L=1	165,144.8568	0.5558	9.9314	0.5933	0.6189	145,680.2372	0.3265	23.5306	0.8375	0.9954
Trigonometric L=2	234,350.1133	0.3696	12.7245	0.7602	0.7160	143,829.6692	0.1745	22.0207	0.7838	1.0114
Trigonometric L=3	202,202.8284	0.4561	11.5282	0.6887	0.6682	152,727.1650	0.2291	23.6186	0.8406	1.0281
Trigonometric L=4	221,649.8163	0.4038	12.3971	0.7406	0.6893	183,657.5704	0.5531	15.9473	0.5676	1.1443
Autocorrelation L=1	202,431.3679	0.3969	11.4596	0.6846	0.6850	149,444.4719	0.2294	23.7100	0.8439	1.0294
Autocorrelation L=2	226,010.7526	0.3222	12.4341	0.7428	0.7194	148,125.7684	0.1628	22.2790	0.7930	1.0169
Autocorrelation L=3	211,711.1059	0.3296	12.2813	0.7337	0.6928	136,250.8775	0.1052	20.4306	0.7272	1.0116
Autocorrelation L=4	207,809.8719	0.3282	12.2738	0.7333	0.6887	140,679.1589	0.1806	14.9470	0.5320	1.0636
Decomp Multiplicative (12)	107,337.6394	0.8069	7.8406	0.4684	0.4814	133,777.6178	0.3624	17.7965	0.6334	0.4814
Decomp Multiplicative (4)	116,878.1488	0.7367	7.8053	0.4663	0.5306	90,684.4269	0.2445	15.0362	0.5352	0.9468
Decomp Additive (12)	100,949.2508	0.7635	7.8682	0.4701	0.4744	130,999.4445	0.3498	17.7626	0.6322	0.9979
Simple Exponential Smoothing	318,198.4920	0.3004	14.2549	0.8516	0.8286	137,639.7809	0.1562	14.9522	0.5322	0.6923
Holt's Trend	289,335.3694	0.5597	13.6651	0.8164	0.8031	126,719.6819	0.0637	15.6908	0.5585	0.6569
Additive Holt-Winters (4)	277,320.5467	0.2539	13.2897	0.7939	0.7856	226,269.9342	0.9198	19.4555	0.6925	0.8882
Additive Holt-Winters (12)	125,626.4061	0.7940	8.9817	0.5366	0.5633	167,819.6411	0.6798	20.0635	0.7141	0.7170
Multiplicative Holt-Winters (4)	277,126.0749	0.2538	13.2887	0.7939	0.7844	227,035.3968	0.9179	19.5229	0.6949	0.8940
Multiplicative Holt-Winters (12)	193,270.9912	0.7050	11.0805	0.6620	0.6930	158,994.6807	N/A	15.1184	0.5381	0.7593
ARIMA (0, 0, 3 - 4)	209,497.7300	0.3910	12.1836	0.7279		209,497.7300	0.3910	12.1836	0.7279	
ARIMA (0, 0, 3 - 12)	129,503.2460	0.4358	11.5000	0.6870		129,503.2460	0.4358	11.5000	0.6870	
ARIMA (3, 0, 3 - 4)	112,067.9870	0.4930	10.4163	0.6223		112,067.9870	0.4930	10.4163	0.6223	
ARIMA (3, 0, 3 - 12)	88,513.2391	0.4468	10.7030	0.6394		88,513.2391	0.4468	10.7030	0.6394	

The Q11 Comparison Chart proved to be fairly evenly distributed between methods and much more difficult to determine which was the best choice. The methods with the most highlighted blocks were Decomposition Multiplicative (12), Decomposition Multiplicative (4), and Additive Holt-Winters (12). Between these three models, Multiplicative (4) scored the highest on more parameters than the other two.

In regards to the validity assumptions, this model passes all requirements. The residual histogram below shows that the data follows a normal bell curve. The plot of the residuals

shows that the model is linear and the variance is fairly constant throughout. Figure 5 displays the residual histogram and plot, along with the Shapiro-Wilk W test.

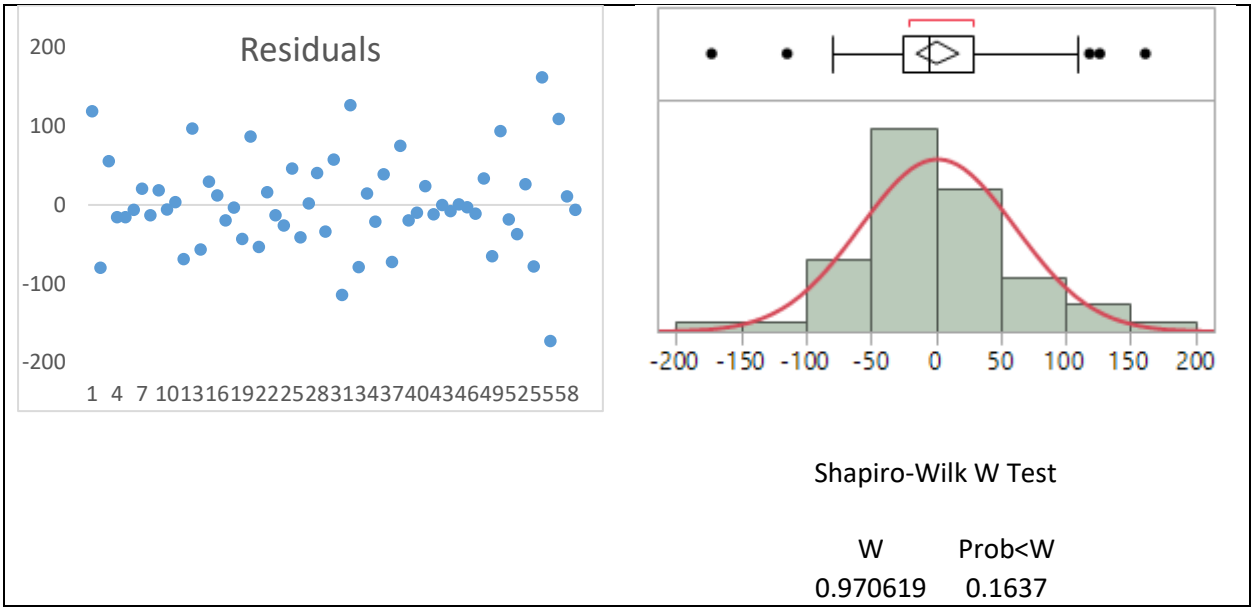

Figure 5. Q11 Validity Assumptions

Figure 6 is a visual representation of the Q11 discrepancies over the last five years in addition to the provided forecast. As in the previous decomposition models, the forecast does well to predict the discrepancy levels into the validation phase.

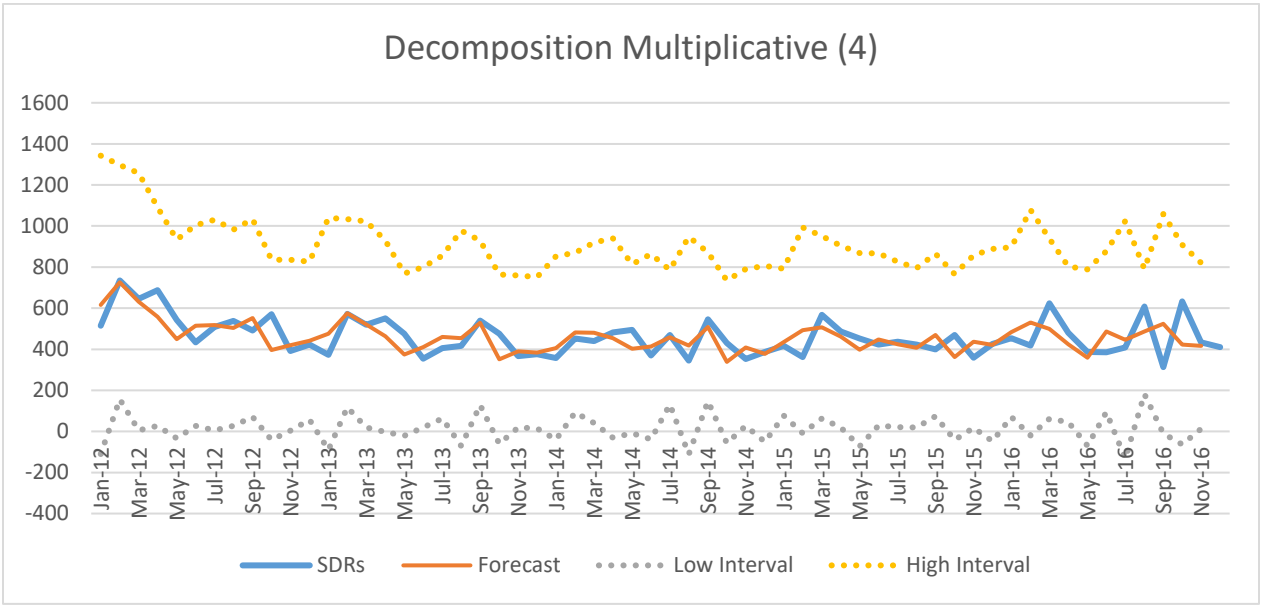

Figure 6. Q11 Forecast

Z3 (Distribution Center Receipt Not Due-In)

The resulting comparison chart for this item is depicted in Table 5.

Table 5. Z3 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	5,421,172.5266	0.4596	165.8844	5.5622	5.2868	36,457,180.0618	0.0797	57.9102	3.4249	3.5034
Trend	462,239.4130	0.9539	35.0332	1.1747	1.2339	144,910,008.9131	N/A	60.5547	3.5813	3.5010
Dummy	1,638,451.3831	0.8367	107.3059	3.5980	3.7567	5,009,516.3154	0.7704	16.5865	0.9810	1.2674
Trigonometric L=1	1,701,664.2321	0.8304	108.7011	3.6448	3.5671	5,018,256.1290	0.7415	16.8574	0.9970	1.2643
Trigonometric L=2	1,121,888.6645	0.8882	77.9661	2.6143	2.2256	9,494,917.8896	N/A	25.6625	1.5177	1.7407
Trigonometric L=3	278,627.5021	0.9722	29.6533	0.9943	0.8766	2,706,582.8697	0.3361	17.9344	1.0607	1.0196
Trigonometric L=4	251,743.3245	0.9749	27.6350	0.9266	0.7961	5,685,630.8389	0.3029	21.4389	1.2679	1.2936
Autocorrelation L=1	541,515.2038	0.8743	40.3534	1.3531	1.1067	3,453,317.8472	0.8075	19.1992	1.1355	1.1198
Autocorrelation L=2	505,024.2823	0.8872	35.5732	1.1928	1.0437	4,768,858.8534	0.8052	21.1255	1.2494	1.3001
Autocorrelation L=3	326,338.1582	0.9738	31.7938	1.0661	0.9741	2,143,940.9441	0.4742	16.2980	0.9639	0.8240
Autocorrelation L=4	343,422.0280	0.9783	29.7906	0.9989	0.9075	5,972,597.1919	N/A	24.4845	1.4480	1.3617
Decomp Multiplicative (12)	212,131.5779	0.9878	20.6478	0.6923	0.7200	1,068,990.2318	0.9380	7.8121	0.4620	0.7200
Decomp Multiplicative (4)	674,193.4078	N/A	31.0890	1.0424	1.5605	534,231.7622	0.9727	5.7305	0.3389	0.4400
Decomp Additive (12)	207,209.2076	0.9548	25.5365	0.8563	0.7512	1,608,508.3620	0.8730	8.8003	0.5205	0.6979
Simple Exponential Smoothing	720,601.0715	0.8450	30.6729	1.0285	0.9763	16,114,692.0366	N/A	33.7657	1.9970	2.1204
Holt's Trend	513,020.7697	N/A	32.9172	1.1037	1.0054	4,185,391.7677	0.3218	17.3359	1.0253	1.1056
Additive Holt-Winters (4)	5,404,629.5737	0.4645	165.3418	5.5440	5.3656	36,445,051.5380	N/A	57.9509	3.4273	3.5017
Additive Holt-Winters (12)	649,727.3272	N/A	60.1586	2.0172	1.3714	2,651,765.7795	0.4195	14.1146	0.8348	0.8887
Multiplicative Holt-Winters (4)	18,349,716.4620	N/A	158.1725	5.3036	1.8816	168,814,663.4150	N/A	163.8434	9.6899	9.2869
Multiplicative Holt-Winters (12)	1,458,722.9186	N/A	64.7282	2.1704	1.9967	41,598,152.8490	N/A	70.0972	4.1457	4.0660
ARIMA (0, 0, 3 - 4)	3,407,531.8500	0.9363	60.2931	2.0217		3,407,531.8500	0.9363	60.2931	2.0217	
ARIMA (0, 0, 3 - 12)	6,529,779.3800	0.8767	102.4760	3.4361		6,529,779.3800	0.8767	102.4760	3.4361	
ARIMA (3, 0, 3 - 4)	157,663,068.0000	0.0000	338.7440	11.3583		157,663,068.0000	N/A	338.7440	11.3583	
ARIMA (3, 0, 3 - 12)	2,084,765.0500	0.9277	61.8048	2.0724		2,084,765.0500	0.9277	61.8048	2.0724	

Again the decomposition models prove to be quite accurate, specifically the Multiplicative (12) and the Additive (12). Between these two models the Decomposition Multiplicative (12) is slightly more accurate than the Additive model, edging it out on 8 of the 10 different parameters.

Ensuring that this model met all validity assumptions proved to be difficult. This was due in large part to the spike in discrepancies beginning in January of 2015. The original data did not pass the normality or constant variance assumptions. The data was first transformed by taking the square root. Unfortunately this only corrected the normality but not the error in variance. A second transformation using the logarithm of the values proved to be successful. By taking the log of all values and running the model again the validity assumptions were met. Figure 7 displays the residuals plot and histogram along with the Shapiro-Wilk W Test result.

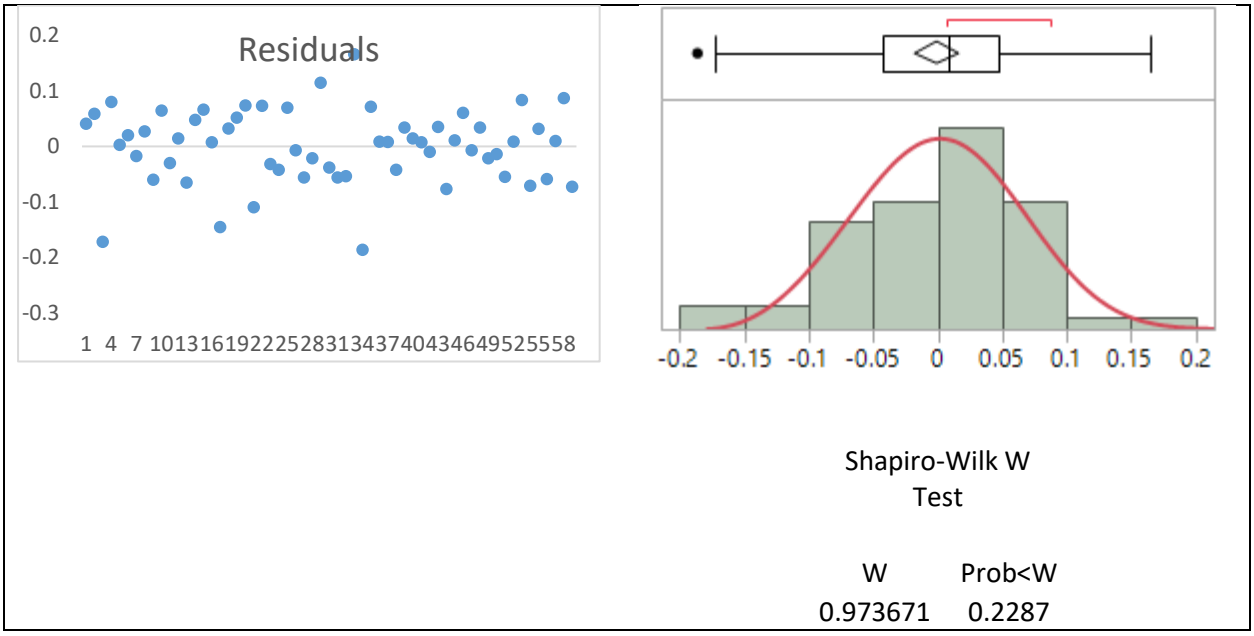

Figure 7. Z3 Validity Assumptions

Figure 8 is a graph of the transformed data and the transformed decomposition forecast. From the beginning of 2015 to the end of 2016 there is a strong observable positive trend in the number of these discrepancies.

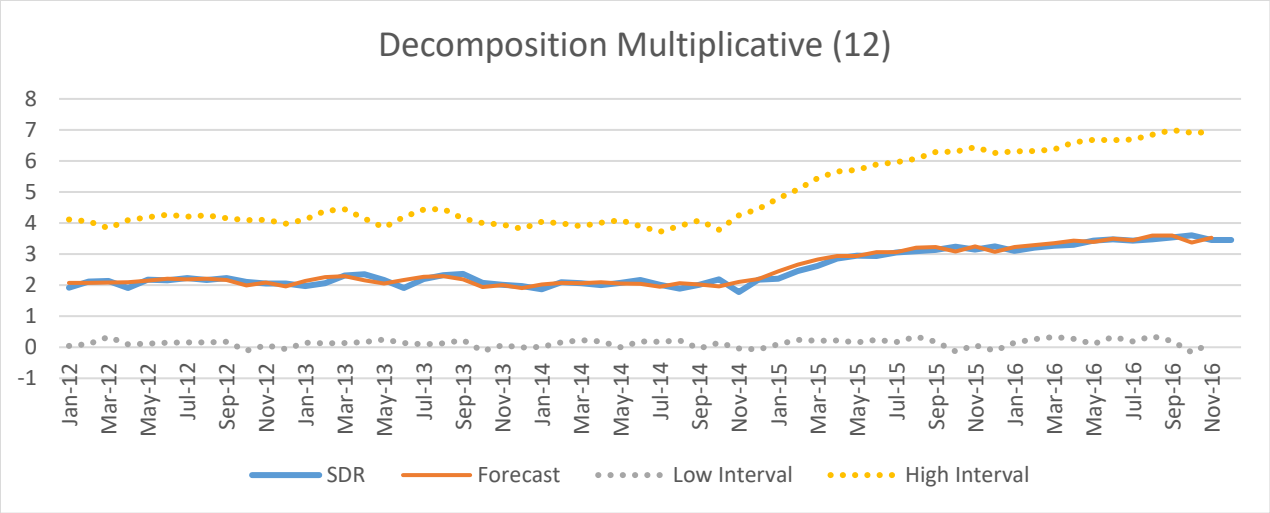

Figure 8. Z3 Forecast

P113 (Electrostatic/Electromagnetic Device Preservation Inadequate or Omitted)

The resulting comparison chart for this item is depicted in Table 6.

Table 6. P113 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	547,765.9791	0.5700	918.2251	8.7270	8.3963	1,053,230.1813	N/A	156.0059	4.2638	4.6866
Trend	443,777.8853	0.6516	541.9315	5.1506	6.2384	3,778,907.6126	N/A	244.0812	6.6710	7.9074
Dummy	332,247.9686	0.7392	749.2357	7.1209	7.2947	253,303.4940	N/A	70.4338	1.9250	2.6174
Trigonometric L=1	346,981.3837	0.7276	695.2192	6.6075	6.9984	256,778.1254	N/A	70.6521	1.9310	2.6410
Trigonometric L=2	255,602.3133	0.7993	516.9129	4.9128	4.8568	87,442.1374	0.1918	27.1052	0.7408	1.7872
Trigonometric L=3	241,864.8892	0.8101	252.2433	2.3974	2.6642	1,681,249.8609	N/A	194.6971	5.3213	5.8435
Trigonometric L=4	392,137.2423	0.6921	491.4584	4.6709	5.3668	9,001,500.8862	N/A	446.2608	12.1968	14.1627
Autocorrelation L=1	248,146.1132	0.7195	426.6123	4.0546	3.4470	153,966.8239	N/A	52.0046	1.4213	2.0378
Autocorrelation L=2	241,909.0066	0.7790	311.9037	2.9644	3.7045	66,550.5110	0.4432	25.0538	0.6848	1.7729
Autocorrelation L=3	272,459.2213	0.7388	348.8045	3.3151	3.4846	356,041.6010	N/A	90.2896	2.4677	2.8390
Autocorrelation L=4	275,752.9628	0.7426	333.0615	3.1655	3.2291	674,866.9078	4.4616	124.9342	3.4146	3.8561
Decomp Multiplicative (12)	72,648.8793	0.9293	58.2910	0.5540	0.5259	148,429.0356	N/A	35.5466	0.9715	0.5259
Decomp Multiplicative (4)	202,104.8571	N/A	50.9013	0.4838	0.4919	25,728.2731	0.7711	19.8526	0.5426	1.6770
Decomp Additive (12)	67,957.8051	0.9076	172.9174	1.6434	2.4441	147,516.2776	N/A	37.2796	1.0189	2.6689
Simple Exponential Smoothing	360,980.3971	0.9631	124.2234	1.1806	0.9996	382,435.2525	N/A	94.5201	2.5833	2.8340
Holt's Trend	358,780.7256	N/A	337.7812	3.2103	2.0564	1,205,419.7456	N/A	165.9634	4.5360	5.1332
Additive Holt-Winters (4)	306,610.6828	0.9907	318.1860	3.0241	3.0947	615,790.2238	N/A	119.0776	3.2545	3.7524
Additive Holt-Winters (12)	236,270.6315	0.9586	501.2674	4.7641	5.1958	922,788.8830	N/A	145.0408	3.9641	4.3189
Multiplicative Holt-Winters (4)	354,268.1057	N/A	125.3312	1.1912	1.2884	550,497,652.5899	N/A	3,377.4924	92.3108	92.7845
Multiplicative Holt-Winters (12)	558,912.2270	N/A	463.7781	4.4078	3.7588	2,513,346.0312	N/A	240.7327	6.5795	6.8933
ARIMA (0, 0, 3 - 4)	324,848.7770	0.7343	328.5562	3.1227		324,848.7770	0.7343	328.5562	3.1227	
ARIMA (0, 0, 3 - 12)	312,921.3950	0.6414	856.5431	8.1407		312,921.3950	0.6414	856.5431	8.1407	
ARIMA (3, 0, 3 - 4)	274,415.3320	0.7386	579.0583	5.5035		274,415.3320	0.7386	579.0583	5.5035	
ARIMA (3, 0, 3 - 12)	55,835.5582	0.7769	216.9510	2.0619		55,835.5582	0.7769	216.9510	2.0619	

The trend of strong decomposition models continues with the forecasting of P113. The most accurate forecast of this data is the Decomposition Multiplicative (4).

The data follows a normal distribution and is linear with little variance, but has one outlier data point on September of 2015. Since this was the only data point outside of the grouping, the researcher decided to omit this data point rather than transform the data. Figure 9 shows a plot of the residuals with the outlier highlighted. The following residual histogram and Shapiro-Wilk W Test result come from after removing the outlier data point.

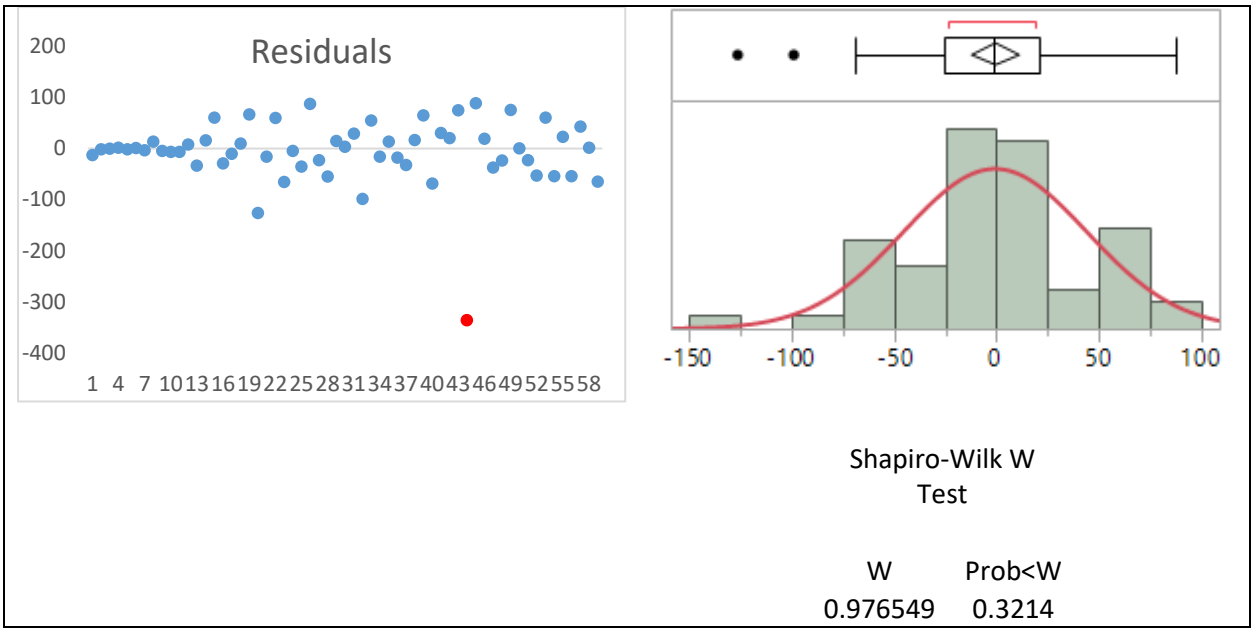

Figure 9. P113 Validity Assumptions

Figure 10 is a graph of the data along with the decomposition forecast.

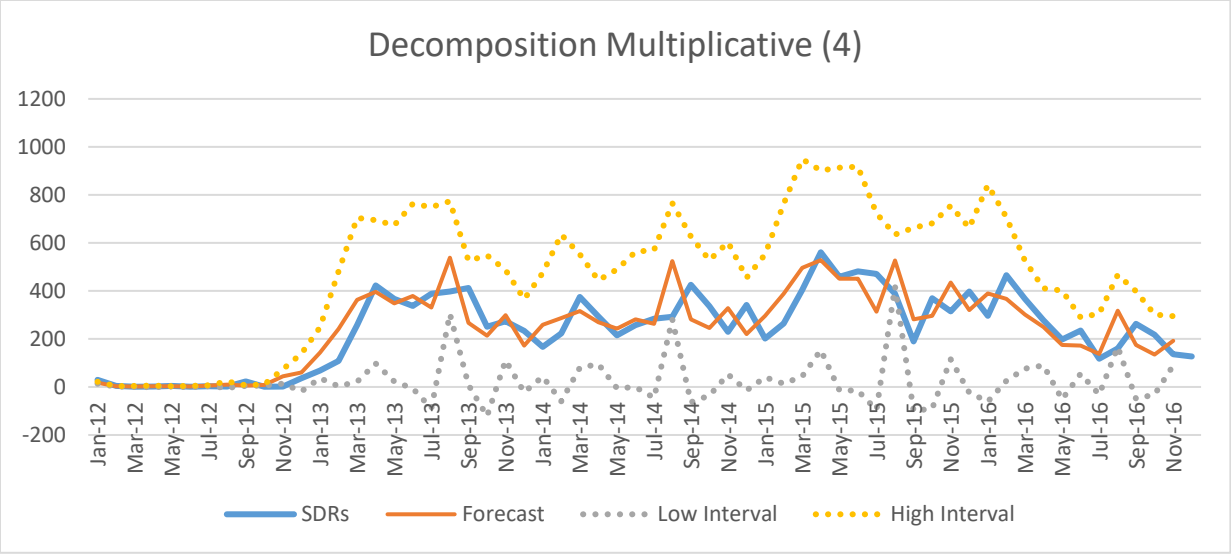

Figure 10. P113 Forecast

P201 (Container Inadequate/Incorrect/Oversized)

The resulting comparison chart for this item is depicted in Table 7.

Table 7. P201 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	294,976.5745	0.3918	180.6555	4.3987	1.5048	323,517.7962	N/A	128.1967	2.7042	2.1094
Trend	126,048.3097	0.7401	74.0497	1.8030	0.5725	6,853,365.5315	N/A	453.1463	9.5587	9.8729
Dummy	146,338.4689	0.6983	110.7826	2.6974	1.1952	79,688.4224	N/A	44.2447	0.9333	1.2632
Trigonometric L=1	168,058.6041	0.6535	126.8388	3.0884	1.1600	74,089.7472	N/A	41.8272	0.8823	1.2654
Trigonometric L=2	100,796.6362	0.7922	60.2302	1.4665	0.3767	324,504.7421	N/A	101.4835	2.1407	2.4224
Trigonometric L=3	101,296.8719	0.7912	44.3003	1.0787	0.3114	825,214.4028	N/A	199.4378	4.2070	3.5815
Trigonometric L=4	111,902.9100	0.7693	69.8270	1.7002	0.4693	2,926,193.5257	N/A	350.5916	7.3954	6.9226
Autocorrelation L=1	133,878.9256	0.6693	86.1467	2.0976	0.5991	79,342.8528	N/A	43.9743	0.9276	1.2516
Autocorrelation L=2	107,078.1783	0.7544	61.4732	1.4968	0.3888	229,214.6269	N/A	82.9857	1.7505	2.0987
Autocorrelation L=3	111,304.9234	0.7552	65.4661	1.5940	0.4373	400,569.5159	N/A	140.2858	2.9592	2.3722
Autocorrelation L=4	113,280.1780	0.7576	64.9296	1.5810	0.4345	1,281,256.0725	N/A	233.7578	4.9309	4.4805
Decomp Multiplicative (12)	53,740.1780	0.9371	26.1891	0.6377	0.1998	15,712.5967	0.6201	24.2020	0.5105	0.1998
Decomp Multiplicative (4)	59,772.2463	0.9595	24.8938	0.6061	0.1627	24,427.3823	0.4288	28.3108	0.5972	0.7401
Decomp Additive (12)	48,022.6251	0.8913	30.9060	0.7525	0.2145	17,631.2425	0.7615	26.6986	0.5632	0.6745
Simple Exponential Smoothing	172,687.7707	0.8779	50.9658	1.2410	0.9522	99,870.9147	N/A	70.0681	1.4780	1.0921
Holt's Trend	172,165.6487	N/A	80.5096	1.9603	0.7842	222,352.3705	N/A	105.0875	2.2167	1.7612
Additive Holt-Winters (4)	159,652.3308	0.8964	53.0365	1.2914	0.9625	187,490.4180	N/A	96.8511	2.0430	1.5655
Additive Holt-Winters (12)	114,740.2419	0.9373	71.1489	1.7324	0.9584	198,583.7069	N/A	98.0606	2.0685	1.6030
Multiplicative Holt-Winters (4)	159,553.7149	0.8975	51.9867	1.2658	0.8589	213,182.9601	N/A	103.8013	2.1896	1.6953
Multiplicative Holt-Winters (12)	166,450.4819	N/A	48.9095	1.1909	0.8552	478,207.2652	N/A	156.0006	3.2907	2.5635
ARIMA (0, 0, 3 - 4)	157,771.5390	0.6490	79.8997	1.9455		157,771.5390	0.6490	79.8997	1.9455	
ARIMA (0, 0, 3 - 12)	173,114.1690	0.6030	119.0623	2.8990		173,114.1690	0.6030	119.0623	2.8990	
ARIMA (3, 0, 3 - 4)	383,704.8000	0.2524	150.6703	3.6686		383,704.8000	0.2524	150.6703	3.6686	
ARIMA (3, 0, 3 - 12)	202,145.6420	0.6062	38.8700	0.9464		202,145.6420	0.6062	38.8700	0.9464	

There were a few different tests that performed well for P201, but the Decomposition Multiplicative (12) model was selected. This decision was made by viewing the number of highlighted parameters per test, and also by comparing the strength of these results against the other models.

The validity assumptions for this model were easily met in all aspects. The residuals plot shows that the data maintains constant variance and linearity. The histogram is a normal distribution and the Shapiro-Wilk W Test is sufficient.

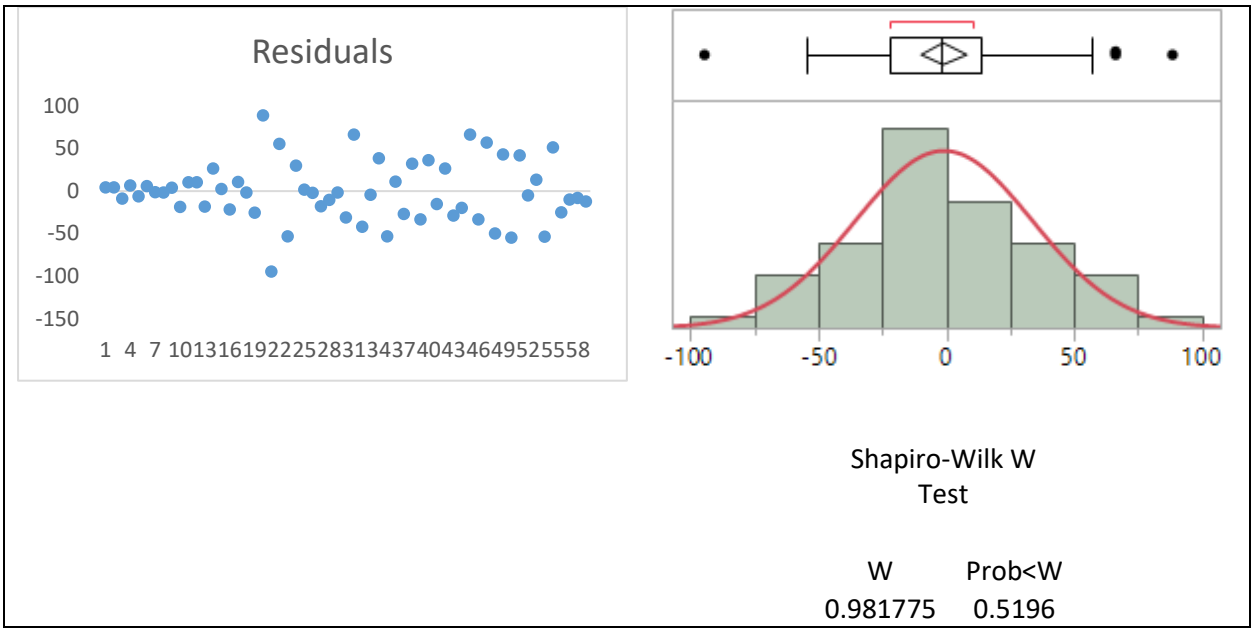

Figure 11. P201 Validity Assumptions

Figure 12 provides a visual representation of the data and the forecast for comparison.

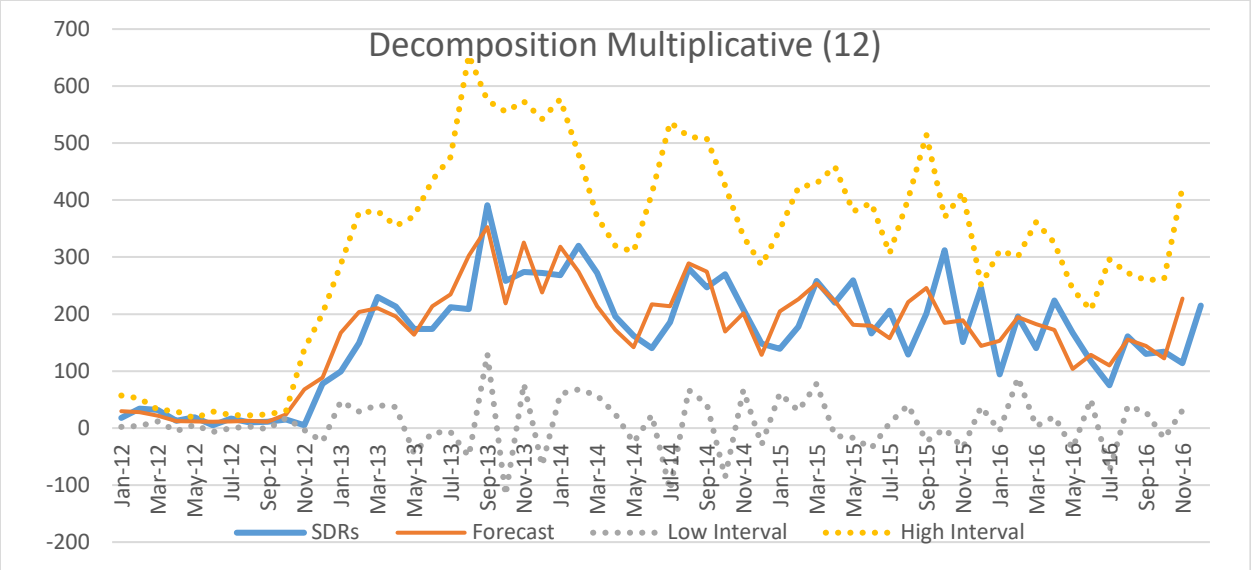

Figure 12. P201 Forecast

P206 (Level of Protection Excessive or Inadequate)

The resulting comparison chart for this item is depicted in Table 8.

Table 8. P206 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	230,389.8183	0.0584	320.4027	6.0618	8.2035	68,761.6354	0.8068	164.9107	3.2848	4.1158
Trend	119,932.6172	0.5099	105.2090	1.9905	2.3872	2,376,353.6704	N/A	848.4944	16.9006	25.8263
Dummy	104,402.2156	0.5733	204.7590	3.8739	1.8086	152,700.7074	N/A	202.4893	4.0333	6.3736
Trigonometric L=1	113,192.4565	0.5374	215.4468	4.0761	3.1494	149,202.2585	N/A	206.2697	4.1086	6.3475
Trigonometric L=2	84,682.8982	0.6539	138.8941	2.6278	2.6606	341,829.2144	N/A	331.5710	6.6044	9.6657
Trigonometric L=3	100,053.2935	0.5911	124.8221	2.3615	2.6590	155,879.3454	N/A	245.5758	4.8915	6.3729
Trigonometric L=4	109,989.0780	0.5505	87.9052	1.6631	1.9132	1,496,596.9194	N/A	736.0284	14.6605	20.8238
Autocorrelation L=1	80,269.1601	0.6108	77.9409	1.4746	1.2114	71,986.1193	N/A	138.2224	2.7532	4.7592
Autocorrelation L=2	85,381.2963	0.6411	80.4680	1.5224	1.2654	155,495.5092	N/A	221.5668	4.4133	6.8223
Autocorrelation L=3	85,271.2064	0.6379	73.6647	1.3937	1.3973	36,365.0914	N/A	117.2060	2.3346	3.0965
Autocorrelation L=4	85,971.5294	0.6393	73.4099	1.3889	1.4235	260,911.1684	N/A	308.4642	6.1441	8.5728
Decomp Multiplicative (12)	13,530.5406	0.8555	27.6888	0.5239	0.3857	6,620.4227	0.6175	36.6192	0.7294	0.3857
Decomp Multiplicative (4)	34,664.1093	0.8615	28.4219	0.5377	0.3623	2,243.6246	0.6178	21.7573	0.4334	1.6565
Decomp Additive (12)	19,533.2322	0.8526	38.7337	0.7328	1.9359	10,056.1215	0.7598	43.0721	0.8579	1.8549
Simple Exponential Smoothing	118,568.2055	0.9249	99.3973	1.8805	0.9401	9,161.6736	0.0793	53.5175	1.0660	1.2907
Holt's Trend	116,956.8805	N/A	87.6739	1.6587	1.2354	49,369.5932	N/A	133.7586	2.6643	3.7554
Additive Holt-Winters (4)	99,361.8891	0.9700	98.3837	1.8613	3.7148	16,209.9047	0.5244	72.0728	1.4356	1.8547
Additive Holt-Winters (12)	76,811.7580	0.9160	110.0481	2.0820	5.2417	52,539.6916	N/A	134.3380	2.6758	3.2576
Multiplicative Holt-Winters (4)	81,414.2188	0.9298	68.0619	1.2877	0.8644	12,895.2257	0.3049	66.9902	1.3343	1.6910
Multiplicative Holt-Winters (12)	92,556.0425	N/A	69.0497	1.3064	2.5702	19,968.3333	0.9432	62.0053	1.2350	2.0623
ARIMA (0, 0, 3 - 4)	97,397.8320	0.6128	106.5954	2.0167		97,397.8320	0.6128	106.5954	2.0167	
ARIMA (0, 0, 3 - 12)	96,563.1824	0.5389	144.9744	2.7428		96,563.1824	0.5389	144.9744	2.7428	
ARIMA (3, 0, 3 - 4)	74,127.5020	0.6483	122.4900	2.3174		74,127.5020	0.6483	122.4900	2.3174	
ARIMA (3, 0, 3 - 12)	62,068.4694	0.5929	122.6011	2.3195		62,068.4694	0.5929	122.6011	2.3195	

The trend of Decomposition Multiplicative continues with this data set, this time with the 4 month variation. Again, the other decomposition models do similarly well, but the Multiplicative (4) performs the best overall.

In regards to the validity assumptions, the residuals from this model were very linear except for two outliers. After removing these outliers all assumptions were met. Figure 13 shows the original residual plot with the outliers highlighted. Also displayed are the residual histogram after the removal of the outliers and the resulting Shapiro-Wilk W statistic.

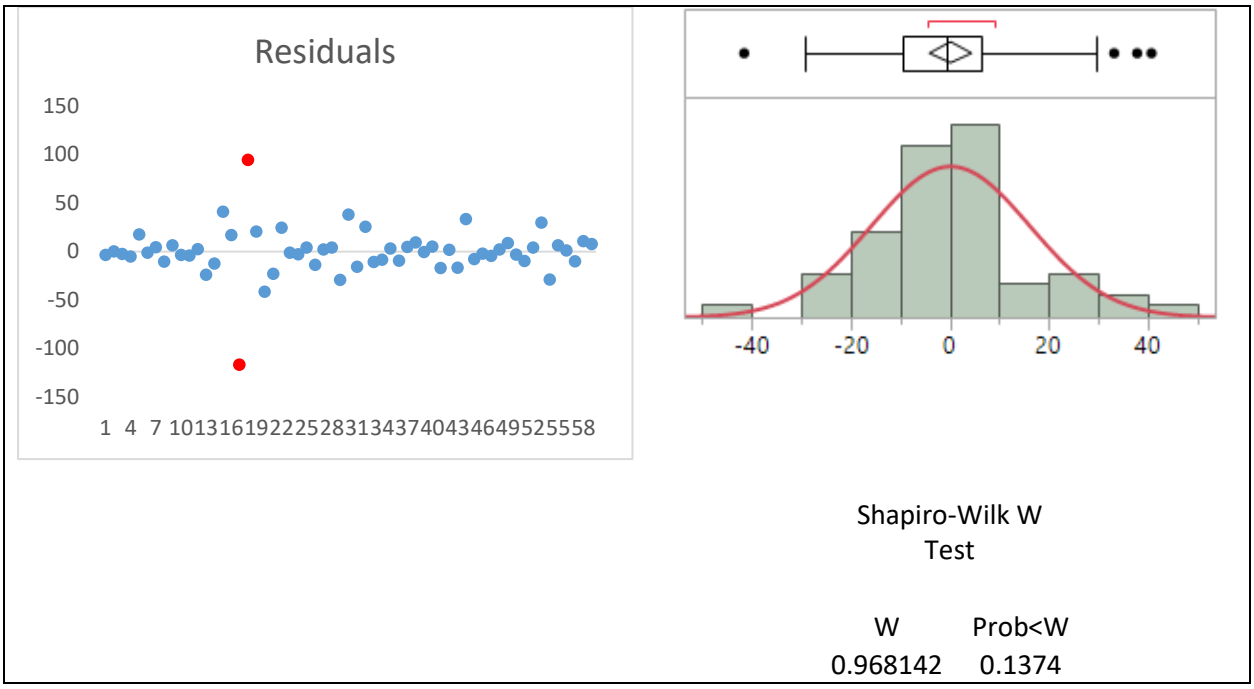

Figure 13. P206 Validity Assumptions

Figure 14 is a visual representation of the data and the selected forecast method.

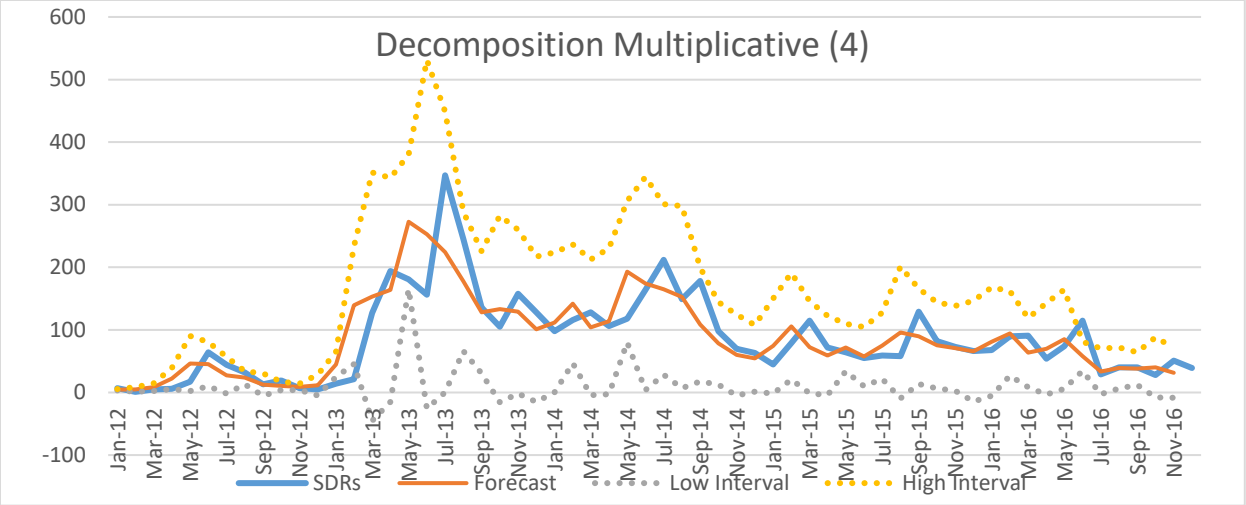

Figure 14. P206 Forecast

P210 (Non-Conformance to Specified Requirements for Packing)

Table 9. P210 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	86,699.2392	0.5151	652.9037	6.5968	2.8917	89,225.2464	N/A	242.8147	3.1599	2.9078
Trend	52,579.1932	0.7059	286.9147	2.8989	1.3507	1,235,244.7836	N/A	878.8301	11.4366	12.9911
Dummy	54,318.6282	0.6962	518.6592	5.2405	2.5593	283,551.7952	N/A	419.3941	5.4578	4.7592
Trigonometric L=1	66,114.6035	0.6302	379.4381	3.8338	2.1925	281,008.8261	N/A	415.1445	5.4025	4.9699
Trigonometric L=2	60,320.4604	0.6626	299.6780	3.0279	1.3209	350,315.4278	N/A	471.6390	6.1377	6.0350
Trigonometric L=3	45,772.5469	0.7440	313.5284	3.1678	1.4121	15,476.3178	0.5106	87.6439	1.1406	0.9037
Trigonometric L=4	50,032.4253	0.7201	180.0222	1.8189	1.1223	11,316.6828	0.5022	54.7145	0.7120	0.6183
Autocorrelation L=1	61,188.7011	0.6758	312.4151	3.1566	1.7653	185,563.2477	N/A	335.4150	4.3649	3.8639
Autocorrelation L=2	57,589.4636	0.6752	228.8613	2.3124	1.0848	247,579.3797	N/A	395.1786	5.1426	4.8698
Autocorrelation L=3	52,858.4094	0.6858	277.6560	2.8054	1.3447	16,645.2134	0.2218	58.9995	0.7678	0.8116
Autocorrelation L=4	51,997.6361	0.6933	271.2906	2.7411	1.3219	175,985.7458	N/A	295.2493	3.8422	4.1109
Decomp Multiplicative (12)	38,397.0357	N/A	73.2196	0.7398	0.5677	36,187.8480	N/A	82.1902	1.0696	0.5677
Decomp Multiplicative (4)	22,912.3771	0.9533	73.1700	0.7393	0.7030	17,490.2894	0.7980	62.0980	0.8081	0.9907
Decomp Additive (12)	20,375.3298	0.8801	438.0002	4.4255	1.8592	20,139.5409	0.8525	81.7375	1.0637	1.3750
Simple Exponential Smoothing	73,947.8881	0.7312	82.4234	0.8328	0.9897	32,883.7655	0.6451	145.9709	1.8996	1.7367
Holt's Trend	74,072.5772	0.7394	79.4949	0.8032	0.9938	31,892.4585	0.6071	143.3645	1.8657	1.7045
Additive Holt-Winters (4)	64,092.2806	0.8281	361.6209	3.6538	1.7832	67,945.0615	N/A	209.8464	2.7308	2.3827
Additive Holt-Winters (12)	50,225.5289	0.8632	566.2139	5.7209	2.3446	69,031.4976	N/A	210.9223	2.7448	2.3304
Multiplicative Holt-Winters (4)	81,583.6490	0.8582	177.8145	1.7966	1.0488	395,676.6247	N/A	480.6247	6.2546	5.1994
Multiplicative Holt-Winters (12)	1,165,320.6271	N/A	1,559.8031	15.7600	11.1419	569,360,364.5013	N/A	16,361.8058	212.9236	170.8052
ARIMA (0, 0, 3 - 4)	79,510.2415	0.6051	298.6355	3.0174		79,510.2415	0.6051	298.6355	3.0174	
ARIMA (0, 0, 3 - 12)	88,923.8732	0.4856	538.9727	5.4457		88,923.8732	0.4856	538.9727	5.4457	
ARIMA (3, 0, 3 - 4)	65,887.3069	0.6588	195.9635	1.9800		65,887.3069	0.6588	195.9635	1.9800	
ARIMA (3, 0, 3 - 12)	45,578.1847	0.6253	221.2343	2.2353		45,578.1847	0.6253	221.2343	2.2353	

The P210 discrepancy data is best modeled by the Decomposition Multiplicative (4) as well. This model scored in the top five of every parameter listed, easily besting the other models provided.

In order to meet all validity assumptions, this model required transformation. The original model had large changes in variance and did not pass normality. Several different transformations were prepared before settling on the 7th root as the best transformation model. Once the model was re-run, it passed all validity assumptions, as can be seen in Figure 15.

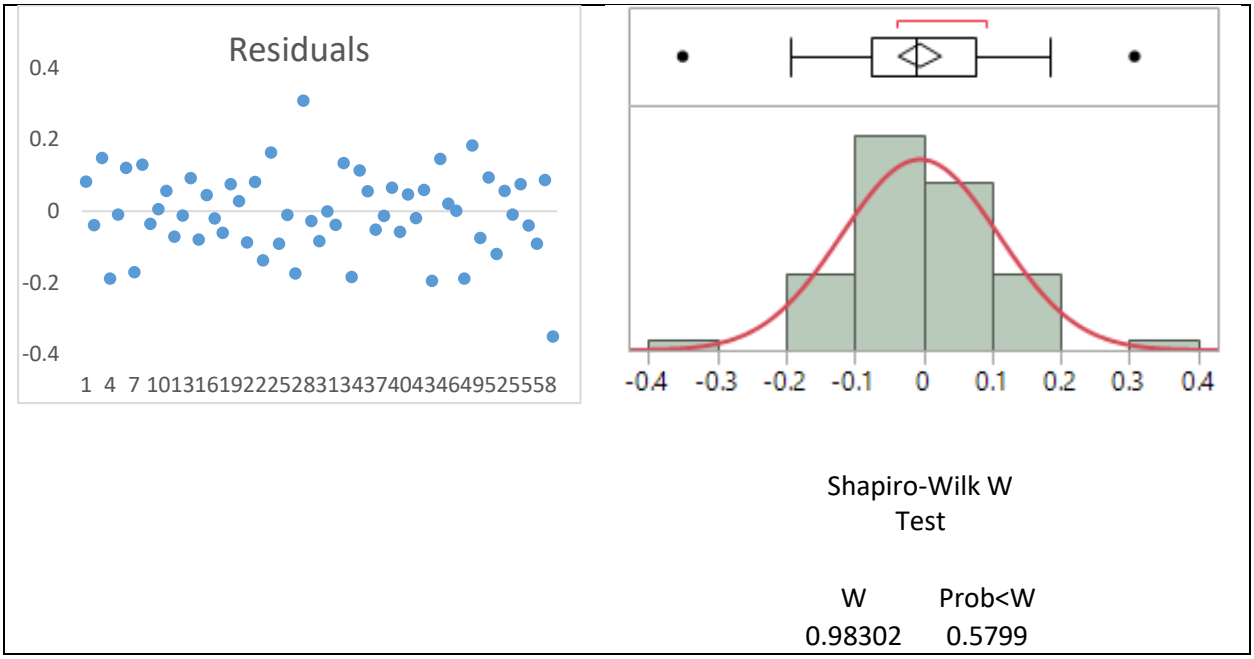

Figure 15. P210 Validity Assumptions

Figure 16 is a visual representation of the data and the forecast model selected after the transformation.

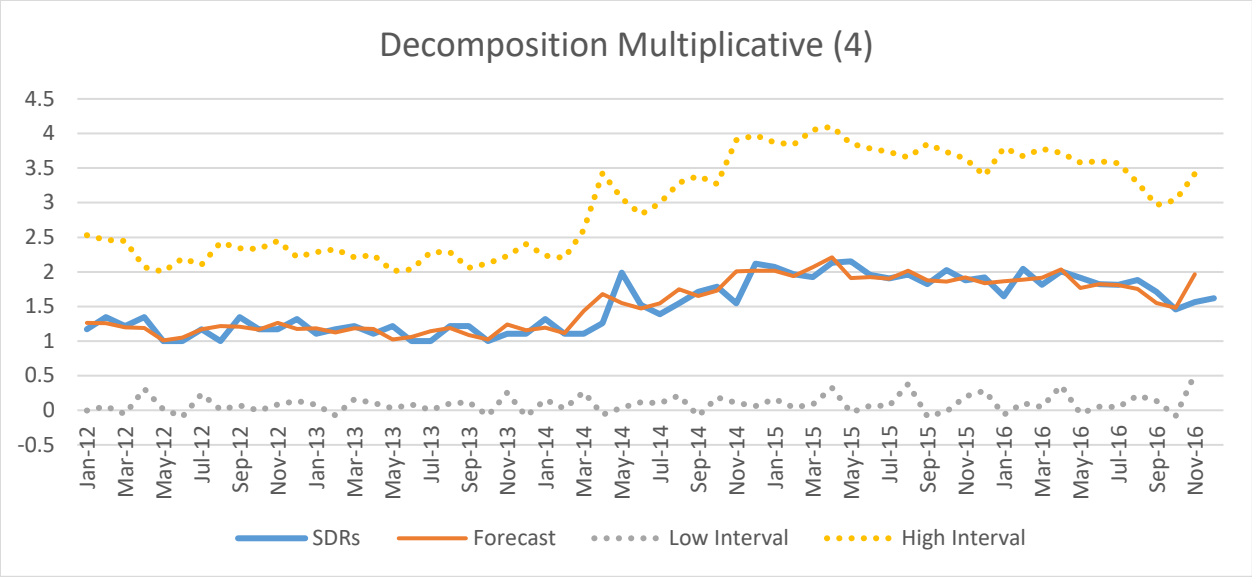

Figure 16. P210 Forecast

P303 (Labels Omitted or Improperly Affixed)

Table 10. P303 Comparison Chart

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	8,077.1445	0.8568	457.0082	17.2811	2.7982	7,166.1215	N/A	25.2085	0.8793	0.5820
Trend	4,656.6591	0.9174	203.8868	7.7097	1.4111	21,500.5230	N/A	52.9707	1.8477	1.6471
Dummy	6,543.5216	0.8840	377.4064	14.2711	2.4963	10,958.6837	0.9293	32.3310	1.1278	0.8295
Trigonometric L=1	7,217.0666	0.8720	385.1288	14.5631	2.3192	10,896.6068	0.9044	31.5091	1.0991	0.8312
Trigonometric L=2	5,247.7715	0.9070	197.7271	7.4768	1.1705	18,904.1648	N/A	43.8847	1.5308	1.1179
Trigonometric L=3	3,319.2719	0.9411	141.6092	5.3547	0.9241	8,618.4057	0.4904	26.5003	0.9244	0.7689
Trigonometric L=4	3,668.9975	0.9349	98.7303	3.7333	0.7965	112,832.2299	N/A	85.2298	2.9729	2.6571
Autocorrelation L=1	5,482.8232	0.9110	217.2918	8.2166	1.3370	10,663.0761	0.8452	28.7173	1.0017	0.7639
Autocorrelation L=2	4,826.5360	0.9057	153.5927	5.8079	0.9275	14,638.8071	N/A	37.4519	1.3064	0.9153
Autocorrelation L=3	4,089.6686	0.9319	130.6841	4.9416	0.9767	8,553.1776	0.5655	25.5222	0.8903	0.7355
Autocorrelation L=4	4,193.9736	0.9324	148.7585	5.6251	1.0752	8,378.9006	0.2309	21.7637	0.7591	0.8228
Decomp Multiplicative (12)	4,216.1806	N/A	33.0503	1.2497	0.4084	6,258.1962	0.6531	19.3399	0.6746	0.4084
Decomp Multiplicative (4)	3,207.0639	0.9819	32.0978	1.2137	0.4330	5,316.4728	0.5771	18.5008	0.6453	0.6961
Decomp Additive (12)	2,098.4529	0.9605	148.7537	5.6249	0.9705	3,018.6427	0.4535	14.6266	0.5102	0.5731
Simple Exponential Smoothing	5,923.0172	0.9289	35.3732	1.3376	1.0013	14,302.4784	0.8302	27.6252	0.9636	0.9613
Holt's Trend	5,673.6135	0.9614	82.8377	3.1324	0.9603	9,586.7164	0.3456	22.7881	0.7949	0.7708
Additive Holt-Winters (4)	5,391.6531	0.9998	202.4544	7.6555	1.2544	6,169.7627	0.1286	19.8882	0.6937	0.5865
Additive Holt-Winters (12)	4,633.1770	0.9982	248.3832	9.3922	1.4172	5,706.5425	0.1257	20.2345	0.7058	0.5275
Multiplicative Holt-Winters (4)	5,656.1099	0.9835	113.9824	4.3101	0.9758	54,085.9840	N/A	77.3093	2.6967	1.9512
Multiplicative Holt-Winters (12)	7,003.4082	N/A	81.3633	3.0766	1.0873	84,960.3526	N/A	94.5830	3.2992	2.6775
ARIMA (0, 0, 3 - 4)	9,545.9326	0.8715	262.2629	9.9171		9,545.9326	0.8715	262.2629	9.9171	
ARIMA (0, 0, 3 - 12)	12,657.1825	0.8293	371.9190	14.0636		12,657.1825	0.8293	371.9190	14.0636	
ARIMA (3, 0, 3 - 4)	5,308.6252	0.9113	137.0851	5.1837		5,308.6252	0.9113	137.0851	5.1837	
ARIMA (3, 0, 3 - 12)	702,488.9230	0.0000	1,670.0000	63.1485		702,488.9230	0.0000	1,670.0000	63.1485	

The final discrepancy studied was P303, and predictably, it followed the common trend of being best modeled by the Decomposition Multiplicative (4) model.

The validity assumptions were not originally met when the model was first built, meaning that a transformation was required in order to meet these requirements. After several different transformation attempts, the best result came from taking the 4^{th} root of the data and running the model on the resulting values. Figure 17 demonstrates the effects of the transformation as all assumptions are now met.

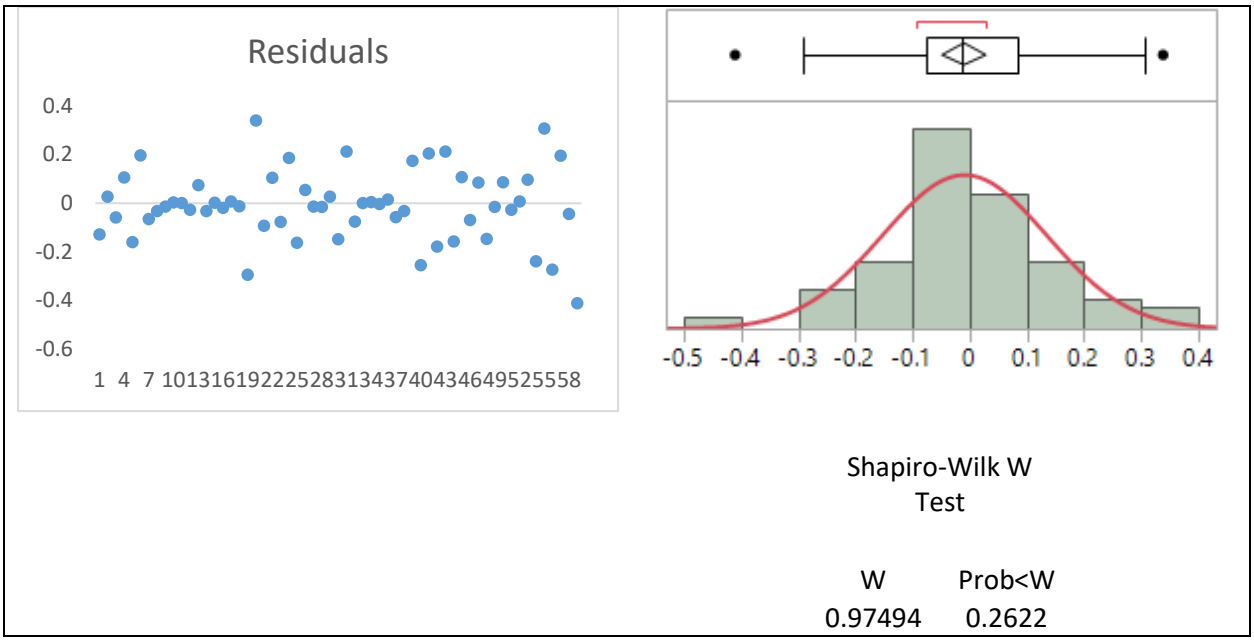

Figure 17. P303 Validity Assumptions

Figure 18 is a graph of the SDR historical data along with the transformed forecast data.

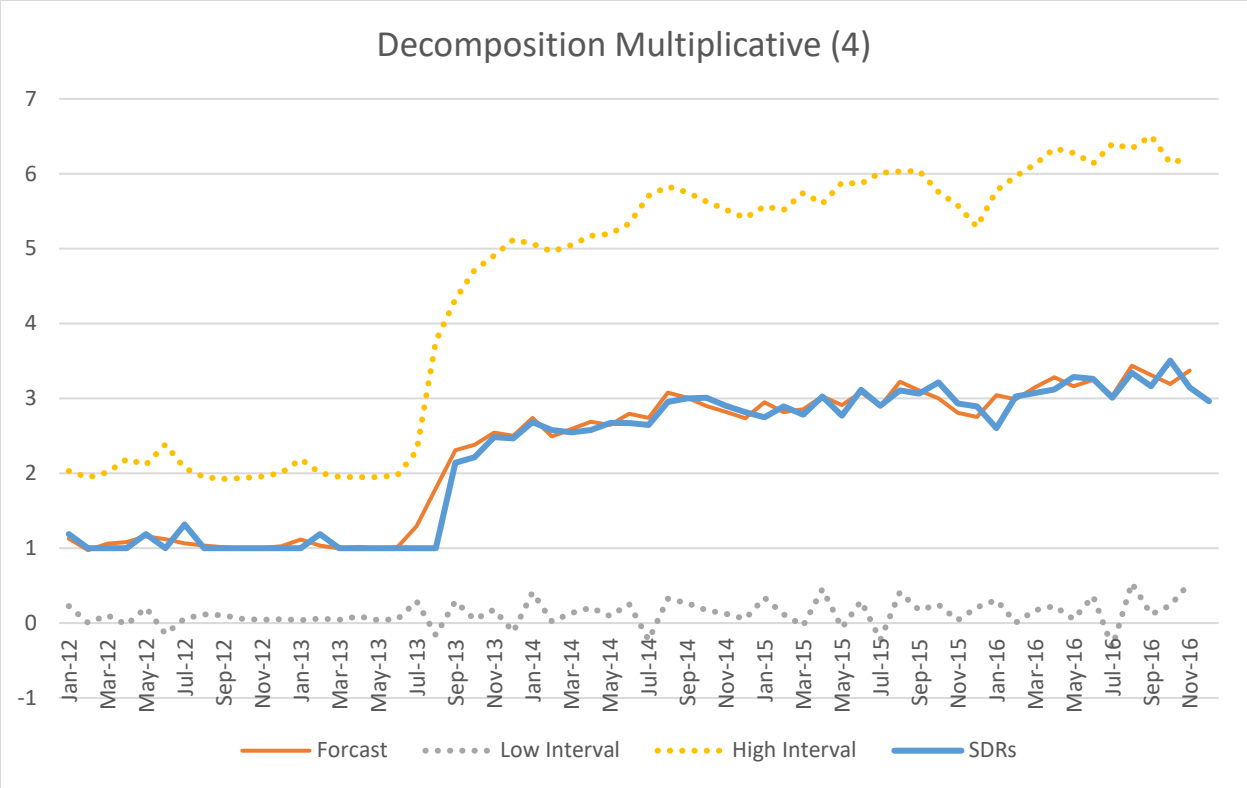

Figure 18. P303 Forecast

Final Analysis

Each of the models tested required a great deal of computational effort to complete, but some proved to be more strenuous than others. A template was built for each model and reused for each individual data set. The first several models (Simple Linear Regression, Trend, Dummy, Trig, Autocorrelation, and Decomposition) required a minimal amount of steps once the template was built. These models simply required the researcher to paste the appropriate data into the spreadsheet and run a regression. The Exponential Smoothing models required an additional step of running Solver in MS Excel. The ARIMA models were built using the JMP software, but proved to be just as strenuous as the Exponential Smoothing models because of compatibility issues, exporting data, and building graphs.

The conclusion of the analysis provided a clear picture to the researcher that the Decomposition forecasting methods performed far better than the other methods. In fact, in all 9 variables, there was never any real competition between decomposition and the other models to determine the most accurate model. The results clearly showed that the decomposition models were far superior. The challenge was actually determining which of the decomposition models to choose from, since they were often very similar in scores.

Of the nine variables studied, the Decomposition Multiplicative (4) was selected a total of six times, making it the clear winner. The Decomposition Multiplicative (12) model was selected twice and the Decomposition Additive (12) was selected once.

V. Discussion

Overview

This study reviewed the existing Supply Discrepancy Reporting issue within the Air Force Installation and Mission Support Center. The intent of this research was to provide AFIMSC with an analysis of the most common and most costly discrepancies using different forecasting methodologies. This forecasting analysis will provide managers at AFIMSC with the tools necessary to project future shipping discrepancies and pinpoint the root cause of these discrepancies.

Current Process

The effort to reduce shipping discrepancies has always been important to AFIMSC. Unfortunately, the organization is not fully prepared to achieve this to the extent required. The SDR process was originally owned and maintained by the Material Management department. Recently, ownership of the program was shifted to the Traffic Management department. This decision was made because leadership felt that Traffic Management held a more central role in the shipment process. The process itself involves both sections, and discrepancies can take place in both. This requires constant communication between each department to prevent mistakes and avoid compounding shipment errors.

When Material Management handed the program over to Traffic Management, it provided details on tracking the SDRs, using/maintaining WebSDR, and general process instructions, but it did not provide details on how to prevent or reduce SDRs. When asked how

to prevent SDRs the general answer is to administer more training. Unfortunately, with an unguided plan of attack, this direction could actually make the situation worse.

Conclusion

This study collected historical data on 9 different shipping discrepancy codes over the last five years. Over 25 different forecasting models were used to predict future shipping discrepancies. These models were all evaluated for accuracy by five separate parameters; SSE R^2, MAPE, RAE, and Theil's U. The model that scored highest among these five parameters for each discrepancy code was chosen to model the historical data. The results of the analysis demonstrated that the Decomposition models proved to be the most accurate, with the Decomposition Multiplicative (4 months) depicting the most accurate forecasts of all models tested.

Recommendations

Administering training to all TMOs and Supply flights Air Force wide is a mistake and should be avoided. Training is important and individual flights should maintain the proper level of training for their respective Airmen, but forcing all offices to cease work and conduct training will slow the process, create cynicism, and won't effectively reduce SDRs. In order to effectively reduce discrepancies, AFIMSC must determine which discrepancies are the biggest offenders, track where these discrepancies are coming from, and focus on these areas to administer training.

AFIMSC can use forecasting techniques to estimate the amount of shipping discrepancies it can expect in future months. Through the use of WebSDR the locations with the most

discrepancies can be identified. Once these locations are identified, AFIMSC will be able to conduct profile forecasts of each location and microforecasts of each discrepancy code. These forecasts will allow managers to determine the likely amount of discrepancies that will occur in the future. If these specific areas are administered training, then the actual discrepancy can be compared to the forecasted amount to determine if the training was successful or not.

Limitations

The study was limited to the quality of available data through the WebSDR database. The researcher made an assumption that the information gathered from the database was indeed correct.

Future Research

There is potential for future research in this field of study. This research observed the total number of discrepancies over time and did not involve any other variables. Future researchers would be able to advance this work by looking at trends from different locations, discrepancy codes that are affected by other discrepancy codes, or even how these discrepancies affect outside agencies, like maintenance.

Appendix A. Naïve Forecast Sample

Month	Time	SDRs	Naïve	Percent Error	Theil's U
12-Jan	1	30			0.866666667
12-Feb	2	4	30	650	0.75
12-Mar	3	1	4	300	-1
12-Apr	4	2	1	50	-1
12-May	5	4	2	50	0.75
12-Jun	6	1	4	300	-2
12-Jul	7	3	1	66.66666667	0.333333333
12-Aug	8	2	3	50	-10.5
12-Sep	9	23	2	91.30434783	0.956521739
12-Oct	10	1	23	2200	-1
12-Nov	11	2	1	50	-17.5
12-Dec	12	37	2	94.59459459	-0.837837838
13-Jan	13	68	37	45.58823529	-0.602941176
13-Feb	14	109	68	37.6146789	-1.366972477
13-Mar	15	258	109	57.75193798	-0.639534884
13-Apr	16	423	258	39.0070922	0.132387707
13-May	17	367	423	15.25885559	0.079019074
13-Jun	18	338	367	8.579881657	-0.147928994
13-Jul	19	388	338	12.88659794	-0.023195876
13-Aug	20	397	388	2.267002519	-0.037783375
13-Sep	21	412	397	3.640776699	0.390776699
13-Oct	22	251	412	64.14342629	-0.087649402
13-Nov	23	273	251	8.058608059	0.146520147
13-Dec	24	233	273	17.16738197	0.283261803
14-Jan	25	167	233	39.52095808	-0.335329341
14-Feb	26	223	167	25.11210762	-0.68161435
14-Mar	27	375	223	40.53333333	0.218666667
14-Apr	28	293	375	27.98634812	0.266211604
14-May	29	215	293	36.27906977	-0.195348837
14-Jun	30	257	215	16.34241245	-0.105058366
14-Jul	31	284	257	9.507042254	-0.028169014
14-Aug	32	292	284	2.739726027	-0.455479452
14-Sep	33	425	292	31.29411765	0.209411765
14-Oct	34	336	425	26.48809524	0.31547619
14-Nov	35	230	336	46.08695652	-0.482608696
14-Dec	36	341	230	32.55131965	0.407624633
15-Jan	37	202	341	68.81188119	-0.306930693
15-Feb	38	264	202	23.48484848	-0.53030303
15-Mar	39	404	264	34.65346535	-0.388613861
15-Apr	40	561	404	27.98573975	0.181818182
15-May	41	459	561	22.22222222	-0.047930283
15-Jun	42	481	459	4.573804574	0.020790021
15-Jul	43	471	481	2.123142251	0.176220807
15-Aug	44	388	471	21.39175258	0.510309278
15-Sep	45	190	388	104.2105263	-0.947368421
15-Oct	46	370	190	48.64864865	0.148648649
15-Nov	47	315	370	17.46031746	-0.26031746
15-Dec	48	397	315	20.65491184	0.25440806
16-Jan	49	296	397	34.12162162	-0.570945946
16-Feb	50	465	296	36.34408602	0.210752688
16-Mar	51	367	465	26.70299728	0.242506812
16-Apr	52	278	367	32.01438849	0.291366906
16-May	53	197	278	41.11675127	-0.192893401
16-Jun	54	235	197	16.17021277	0.49787234
16-Jul	55	118	235	99.15254237	-0.355932203
16-Aug	56	160	118	26.25	-0.64375
16-Sep	57	263	160	39.1634981	0.171102662
16-Oct	58	218	263	20.64220183	0.376146789
16-Nov	59	136	218	60.29411765	0.066176471
16-Dec	60	127	136	7.086614173	
				MAPE Historical	Theil's U Historical
		Average		105.2168688	433.4564241
		240.45		MAPE Forecast	Theil's U Forecast
				36.58825263	1.515428577

Appendix B. Simple Linear Regression Sample

Month	Time	# of SDRs	x-avgerage(x)	y-avgerage(y)	(x-avgerage(x))^2	(y-avgerage(y))^2	Predicted	Pred-Ave(y)	(K)^2	Residual	Percent Error	Theil's U
12-Jan	1	30	-23.5	-210.9791667	552.25	44512.20877	32.35544218	-208.6237245	43523.85842	2.355442177	7.851473923	1.241101582
12-Feb	2	4	-22.5	-236.9791667	506.25	56159.12543	41.23304747	-199.7461192	39898.51213	37.23304747	930.8261869	12.27766319
12-Mar	3	1	-21.5	-239.9791667	462.25	57590.00043	50.11065277	-190.8685139	36430.7896	49.11065277	4911.065277	56.98825807
12-Apr	4	2	-20.5	-238.9791667	420.25	57111.0421	58.98825807	-181.9909086	33120.69081	56.98825807	2849.412903	31.93293168
12-May	5	4	-19.5	-236.9791667	380.25	56159.12543	67.86586337	-173.1133033	29968.21578	63.86586337	1596.646584	18.93586717
12-Jun	6	1	-18.5	-239.9791667	342.25	57590.00043	76.74346866	-164.235698	26973.3645	75.74346866	7574.346866	82.62107396
12-Jul	7	3	-17.5	-237.9791667	306.25	56634.08377	85.62107396	-155.3580927	24136.13697	82.62107396	2754.035799	30.83289309
12-Aug	8	2	-16.5	-238.9791667	272.25	57111.0421	94.49867926	-146.4804874	21456.53319	92.49867926	4624.933963	40.18814228
12-Sep	9	23	-15.5	-217.9791667	240.25	47514.9171	103.3762846	-137.6028821	18934.55317	80.37628456	349.4621068	4.837125646
12-Oct	10	1	-14.5	-239.9791667	210.25	57590.00043	112.2538899	-128.7252768	16570.19689	111.2538899	11125.38899	119.1314952
12-Nov	11	2	-13.5	-238.9791667	182.25	57111.0421	121.1314952	-119.8476715	14363.46437	119.1314952	5956.574758	46.50455022
12-Dec	12	37	-12.5	-203.9791667	156.25	41607.50043	130.0091004	-110.9700662	12314.3556	93.00910045	251.3759472	1.915856912
13-Jan	13	68	-11.5	-172.9791667	132.25	29921.7921	138.8867057	-102.0924609	10422.87058	70.88670575	104.2451555	0.570063398
13-Feb	14	109	-10.5	-131.9791667	110.25	17418.50043	147.764311	-93.21485562	8689.009309	38.76431104	35.56358811	-0.929890676
13-Mar	15	258	-9.5	17.02083333	90.25	289.7087674	156.6419163	-84.33725033	7112.771792	-101.3580837	39.28607894	-0.99798635
13-Apr	16	423	-8.5	182.0208333	72.25	33131.58377	165.5195216	-75.45964503	5694.158028	-257.4804784	60.87008945	-0.455325941
13-May	17	367	-7.5	126.0208333	56.25	15881.25043	174.3971269	-66.58203973	4433.168015	-192.6028731	52.48034688	-0.421594735
13-Jun	18	338	-6.5	97.02083333	42.25	9413.042101	183.2747322	-57.70443443	3329.801753	-154.7252678	45.77670644	-0.579430954
13-Jul	19	388	-5.5	147.0208333	30.25	21615.12543	192.1523375	-48.82682914	2384.059243	-195.8476625	50.47620167	-0.505077467
13-Aug	20	397	-4.5	156.0208333	20.25	24342.50043	201.0299428	-39.94922384	1595.940485	-195.9700572	49.3627348	-0.509048997
13-Sep	21	412	-3.5	171.0208333	12.25	29248.12543	209.9075481	-31.07161854	965.4454788	-202.0924519	49.05156599	-0.078191375
13-Oct	22	251	-2.5	10.02083333	6.25	100.4171007	218.7851534	-22.19401324	492.5742239	-32.21484658	12.83460023	-0.180626459
13-Nov	23	273	-1.5	32.02083333	2.25	1025.333767	227.6627587	-13.31640795	177.3267206	-45.33724128	16.60704809	0.012968366
13-Dec	24	233	-0.5	-7.979166667	0.25	63.66710069	236.540364	-4.438802649	19.70296895	3.540364018	1.519469536	0.336557808
14-Jan	25	167	0.5	-73.97916667	0.25	5472.917101	245.4179693	4.438802649	19.70296895	78.41796932	46.95686785	0.18739865
14-Feb	26	223	1.5	-17.97916667	2.25	323.250434	254.2955746	13.31640795	177.3267206	31.29557461	14.03388996	-0.501465561
14-Mar	27	375	2.5	134.0208333	6.25	17961.58377	263.1731799	22.19401324	492.5742239	-111.8268201	29.82048536	-0.055864573
14-Apr	28	293	3.5	52.02083333	12.25	2706.167101	272.0507852	31.07161854	965.4454788	-20.94921479	7.149902659	0.225011572
14-May	29	215	4.5	-25.97916667	20.25	674.9171007	280.9283905	39.94922384	1595.940485	65.92839051	30.66436768	0.152586027
14-Jun	30	257	5.5	16.02083333	30.25	256.6671007	289.8059958	48.82682914	2384.059243	32.8059958	12.76497891	0.057134635
14-Jul	31	284	6.5	43.02083333	42.25	1850.792101	298.6836011	57.70443443	3329.801753	14.6836011	5.170282077	0.05479298
14-Aug	32	292	7.5	51.02083333	56.25	2603.125434	307.5612064	66.58203973	4433.168015	15.5612064	5.329180273	-0.371784891
14-Sep	33	425	8.5	184.0208333	72.25	33863.6671	316.4388117	75.45964503	5694.158028	-108.5611883	25.54380901	-0.025137842
14-Oct	34	336	9.5	95.02083333	90.25	9028.958767	325.316417	84.33725033	7112.771792	-10.68358301	3.1796378	0.310101257
14-Nov	35	230	10.5	-10.97916667	110.25	120.5421007	334.1940223	93.21485562	8689.009309	104.1940223	45.30174882	0.009007076
14-Dec	36	341	11.5	100.0208333	132.25	10004.1671	343.0716276	102.0924609	10422.87058	2.071627587	0.607515421	0.439733821
15-Jan	37	202	12.5	-38.97916667	156.25	1519.375434	351.9492329	110.9700662	12314.3556	149.9492329	74.23229351	0.479340783
15-Feb	38	264	13.5	23.02083333	182.25	529.9587674	360.8268382	119.8476715	14363.46437	96.82683818	36.67683264	-0.129907411
15-Mar	39	404	14.5	163.0208333	210.25	26575.7921	369.7044435	128.7252768	16570.19689	-34.29555652	8.488999139	-0.451529582
15-Apr	40	561	15.5	320.0208333	240.25	102413.3338	378.5820488	137.6028821	18934.55317	-182.4179512	32.51656885	-0.127522898
15-May	41	459	16.5	218.0208333	272.25	47533.08377	387.4596541	146.4804874	21456.53319	-71.54034593	15.58613201	-0.184450415
15-Jun	42	481	17.5	240.0208333	306.25	57610.00043	396.3372594	155.3580927	24136.13697	-84.66274063	17.60140138	-0.136767433
15-Jul	43	471	18.5	230.0208333	342.25	52909.58377	405.2148647	164.235698	26973.3645	-65.78513533	13.96712003	0.055398025
15-Aug	44	388	19.5	147.0208333	380.25	21615.12543	414.09247	173.1133033	29968.21578	26.09246997	6.724863393	0.600438338
15-Sep	45	190	20.5	-50.97916667	420.25	2598.875434	422.9700753	181.9909086	33120.69081	232.9700753	122.6158291	0.325514108
15-Oct	46	370	21.5	129.0208333	462.25	16646.37543	431.8476806	190.8685139	36430.7896	61.84768056	16.71558934	0.33979807
15-Nov	47	315	22.5	74.02083333	506.25	5479.083767	440.7252859	199.7461192	39898.51213	125.7252859	39.91278916	0.166993305
15-Dec	48	397	23.5	156.0208333	552.25	24342.50043	449.6028912	208.6237245	43523.85842	52.60289116	13.25009853	0.409270772
16-Jan	49	296		55.02083333		3027.292101	458.4804965	217.5013298	47306.82846	162.4804965	54.89205961	0.00796656
16-Feb	50	465		224.0208333		50185.33377	467.3581018	226.3789351	51247.42225	2.358101751	0.507118656	0.234915499
16-Mar	51	367		126.0208333		15881.25043	476.235707	235.2565404	55345.63979	109.235707	29.76449783	0.564341451
16-Apr	52	278		37.02083333		1370.542101	485.1133123	244.1341457	59601.48109	207.1133123	74.50119149	1.068312653
16-May	53	197		-43.97916667		1934.167101	493.9909176	253.011751	64014.94613	296.9909176	150.756811	1.359738695
16-Jun	54	235		-5.979166667		35.75043403	502.8685229	261.8893563	68586.03493	267.8685229	113.9866055	1.675515439
16-Jul	55	118		-122.9791667		15123.87543	511.7461282	270.7669616	73314.74748	393.7461282	333.6831595	3.056133335
16-Aug	56	160		-80.97916667		6557.625434	520.6237335	279.6445669	78201.08378	360.6237335	225.3898335	1.665633368
16-Sep	57	263		22.02083333		484.9171007	529.5013388	288.5221722	83245.04383	266.5013388	101.3313075	1.21817089
16-Oct	58	218		-22.97916667		528.0421007	538.3789441	297.3997775	88446.62764	320.3789441	146.9628184	1.886497933
16-Nov	59	136		-104.9791667		11020.62543	547.2565494	306.2773828	93805.83519	411.2565494	302.3945216	3.155398197
16-Dec	60	127		-113.9791667		12991.25043	556.1341547	315.1549881	99322.6665	429.1341547	337.9009092	
Average	24.5	240.979167			SSxx	Total Variation			Explained Variation			
					9212.00	1273780.979			726015			

Appendix C. Trend Sample

Month	# of SDRs	X	X^2	X^3	X^4	Explained delta	Total delta	Percentage Error	Low Interval	High Interval	Theil's U
Jan-12	30	1	1	1	1	75913.41626	44512.20877	215.1490917	-241.0342328	171.9447778	-1.02054
Feb-12	4	2	4	8	16	71607.22563	56159.12543	765.402448	-233.1056032	179.8734074	-4.36152
Mar-12	1	3	9	27	81	66267.75791	57590.00043	1744.608055	-222.9355858	190.0434247	-6.34022
Apr-12	2	4	16	64	256	60181.60257	57111.0421	317.0111121	-210.8297275	202.149283	2.705256
May-12	4	5	25	125	625	53624.04199	56159.12543	135.2627913	-197.0789936	215.9000169	5.882434
Jun-12	1	6	36	216	1296	46850.3555	57590.00043	2352.973724	-181.959768	231.0192425	37.75565
Jul-12	3	7	49	343	2401	40089.45579	56634.08377	1258.521737	-165.7338532	247.2451574	18.61368
Aug-12	2	8	64	512	4096	33539.57517	57111.0421	2792.051764	-148.64847	264.3305406	26.27662
Sep-12	23	9	81	729	6561	27365.73479	47514.9171	228.4923796	-130.936258	282.0427526	4.029314
Oct-12	1	10	100	1000	10000	21698.74431	57590.00043	9267.423019	-112.8152751	300.1637355	110.0005
Nov-12	2	11	121	1331	14641	16635.49455	57111.0421	5500.02537	-94.4889979	318.4900127	46.67159
Dec-12	37	12	144	1728	20736	12240.32069	41607.50043	252.2788753	-76.14632144	336.8326891	2.176431
Jan-13	68	13	169	2197	28561	8547.228208	29921.7921	118.42345	-57.96155932	355.0174513	0.844045
Feb-13	109	14	196	2744	38416	5562.788721	17418.50043	52.65601987	-40.09444363	372.8845669	-0.68074
Mar-13	258	15	225	3375	50625	3269.527975	289.7087674	28.75993014	-22.69012504	390.2888855	-0.86198
Apr-13	423	16	256	4096	65536	1629.642765	33131.58377	52.57438946	-5.879172704	407.0998379	-0.35529
May-13	367	17	289	4913	83521	588.8987287	15881.25043	40.95042753	10.22242568	423.2014363	-0.28882
Jun-13	338	18	324	5832	104976	80.57571221	9413.042101	31.36012747	25.51326387	438.4922744	-0.41895
Jul-13	388	19	361	6859	130321	29.34232622	21615.12543	36.49587051	39.90651713	452.8855277	-0.35356
Aug-13	397	20	400	8000	160000	354.9561801	24342.50043	34.55429535	53.32994217	466.3089527	-0.3521
Sep-13	412	21	441	9261	194481	975.701177	29248.12543	33.92830523	65.72587717	478.7048877	0.078982
Oct-13	251	22	484	10648	234256	1811.488128	100.4171007	12.96444107	77.05124181	490.0302524	0.082737
Nov-13	273	23	529	12167	279841	2786.559834	1025.333767	7.606975271	87.2775372	500.2565478	0.255972
Dec-13	233	24	576	13824	331776	3831.756653	63.66710069	29.99156706	96.39084597	509.3698565	0.617516
Jan-14	167	25	625	15625	390625	4886.313482	5472.917101	86.1564895	104.3918322	517.3708428	0.567576
Feb-14	223	26	676	17576	456976	5899.173925	323.250434	42.50459492	111.2957414	524.274752	-0.2304
Mar-14	375	27	729	19683	531441	6829.822346	17961.58377	13.7008251	117.1324006	530.1114112	0.094495
Apr-14	293	28	784	21952	614656	7648.649354	2706.167101	12.09410362	121.9462183	534.9252289	0.400292
May-14	215	29	841	24389	707281	8336.881171	674.9171007	54.55148364	125.7961845	538.7751951	0.363932
Jun-14	257	30	900	27000	810000	8886.118211	256.6671007	30.44567157	128.7558707	541.7348812	0.207794
Jul-14	284	31	961	29791	923521	9297.543077	1850.792101	18.80385031	130.9134296	543.8924402	0.165004
Aug-14	292	32	1024	32768	1048576	9580.873073	2603.125434	16.04832227	132.3715957	545.3506063	-0.292
Sep-14	425	33	1089	35937	1185921	9753.147217	33863.6671	20.06183759	133.2476849	546.2266955	0.009796
Oct-14	336	34	1156	39304	1336336	9837.452592	9028.958767	1.239017798	133.6735945	546.6526051	0.32823
Nov-14	230	35	1225	42875	1500625	9861.709818	120.5421007	47.95013416	133.7958033	546.7748139	-0.0032
Dec-14	341	36	1296	46656	1679616	9857.652231	10004.1671	0.215578659	133.7753715	546.7543821	0.405506
Jan-15	202	37	1369	50653	1874161	9860.148313	1519.375434	68.45418127	133.7879409	546.7669515	0.378778
Feb-15	264	38	1444	54872	2085136	9907.03175	529.9587674	28.98228787	134.0237347	547.0027453	-0.23797
Mar-15	404	39	1521	59319	2313441	10039.6184	26575.7921	15.55023196	134.6875576	547.6665682	-0.54087
Apr-15	561	40	1600	64000	2560000	10304.10436	102413.3338	38.95039198	135.9987957	548.9778063	-0.20378
May-15	459	41	1681	68921	2825761	10754.05407	47533.08377	24.9061172	138.1914167	551.1704273	-0.28975
Jun-15	481	42	1764	74088	3111696	11454.20258	57610.00043	27.65000519	141.5139697	554.4929803	-0.24591
Jul-15	471	43	1849	79507	3418801	12485.8106	52909.58377	25.11271962	146.2295853	559.2085959	-0.06135
Aug-15	388	44	1936	85184	3748096	13953.82607	21615.12543	7.447041049	152.6159754	565.594986	0.457358
Sep-15	190	45	2025	91125	4100625	15996.12099	2598.875434	93.39733631	160.9654337	573.9444443	0.042497
Oct-15	370	46	2116	97336	4477456	18795.08665	16646.37543	2.182254152	171.5848351	584.5638456	0.206176
Nov-15	315	47	2209	103823	4879681	22591.88601	5479.083767	24.21750517	184.795636	597.7746466	0.03309
Dec-15	397	48	2304	110592	5308416	27703.67606	24342.50043	2.625536458	200.9338744	613.912885	0.329571
Jan-16	296	49				35534.64088	3325.444444	44.20259293	220.3501698	633.3291804	-0.05102
Feb-16	465	50				44760.12788	51377.77778	3.247477804	243.4097229	656.3887335	0.23652
Mar-16	367	51				56953.10089	16555.11111	29.96779877	270.4923162	683.4713268	0.628016
Apr-16	278	52				72980.20414	1573.444444	82.90712903	301.9923134	714.971324	1.251109
May-16	197	53				93926.82255	1708.444444	176.5523681	338.3186599	751.2976705	1.783677
Jun-16	235	54				121139.5364	11.11111111	149.5252713	379.8948824	792.8738929	2.194249
Jul-16	118	55				156274.1556	14480.11111	436.9903342	427.1590891	840.1380997	4.466555
Aug-16	160	56				201349.7656	6136.111111	329.4084219	480.5639698	893.5429804	3.025414
Sep-16	263	57				258809.2323	608.4444444	184.0556277	540.5767957	953.5558062	2.266802
Oct-16	218	58				331586.6282	413.4444444	273.4719838	607.6794193	1020.65843	3.453476
Nov-16	136	59				423182.0559	10472.11111	553.5718972	682.3682749	1095.347285	6.210617
Dec-16	127	60				537744.3626	12395.11111	665.0739238	765.154378	1178.133389	

Appendix D. Dummy Sample

				Dummy Variables												
Month	# of SDRs	X	X^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Explained Delta	Total Delta
Jan-12	30	1	1	1	0	0	0	0	0	0	0	0	0	0	137203.5451	44512.21
Feb-12	4	2	4	0	1	0	0	0	0	0	0	0	0	0	107898.5159	56159.13
Mar-12	1	3	9	0	0	1	0	0	0	0	0	0	0	0	44225.3418	57590
Apr-12	2	4	16	0	0	0	1	0	0	0	0	0	0	0	19984.72685	57111.04
May-12	4	5	25	0	0	0	0	1	0	0	0	0	0	0	36552.26756	56159.13
Jun-12	1	6	36	0	0	0	0	0	1	0	0	0	0	0	30452.2042	57590
Jul-12	3	7	49	0	0	0	0	0	0	1	0	0	0	0	22074.44903	56634.08
Aug-12	2	8	64	0	0	0	0	0	0	0	1	0	0	0	24537.29621	57111.04
Sep-12	23	9	81	0	0	0	0	0	0	0	0	1	0	0	24091.0684	47514.92
Oct-12	1	10	100	0	0	0	0	0	0	0	0	0	1	0	28741.13416	57590
Nov-12	2	11	121	0	0	0	0	0	0	0	0	0	0	1	38162.10295	57111.04
Dec-12	37	12	144	0	0	0	0	0	0	0	0	0	0	0	19507.80828	41607.5
Jan-13	68	13	169	1	0	0	0	0	0	0	0	0	0	0	25597.26082	29921.79
Feb-13	109	14	196	0	1	0	0	0	0	0	0	0	0	0	15338.28133	17418.5
Mar-13	258	15	225	0	0	1	0	0	0	0	0	0	0	0	131.198481	289.7088
Apr-13	423	16	256	0	0	0	1	0	0	0	0	0	0	0	2671.797597	33131.58
May-13	367	17	289	0	0	0	0	1	0	0	0	0	0	0	15.34242884	15881.25
Jun-13	338	18	324	0	0	0	0	0	1	0	0	0	0	0	48.674111	9413.042
Jul-13	388	19	361	0	0	0	0	0	0	1	0	0	0	0	735.5111073	21615.13
Aug-13	397	20	400	0	0	0	0	0	0	0	1	0	0	0	175.9319097	24342.5
Sep-13	412	21	441	0	0	0	0	0	0	0	0	1	0	0	79.34457717	29248.13
Oct-13	251	22	484	0	0	0	0	0	0	0	0	0	1	0	125.4135258	100.4171
Nov-13	273	23	529	0	0	0	0	0	0	0	0	0	0	1	1832.284583	1025.334
Dec-13	233	24	576	0	0	0	0	0	0	0	0	0	0	0	50.24585733	63.6671
Jan-14	167	25	625	1	0	0	0	0	0	0	0	0	0	0	361.7566759	5472.917
Feb-14	223	26	676	0	1	0	0	0	0	0	0	0	0	0	128.5156259	323.2504
Mar-14	375	27	729	0	0	1	0	0	0	0	0	0	0	0	13910.51554	17961.58
Apr-14	293	28	784	0	0	0	1	0	0	0	0	0	0	0	30729.81793	2706.167
May-14	215	29	841	0	0	0	0	1	0	0	0	0	0	0	12974.48556	674.9171
Jun-14	257	30	900	0	0	0	0	0	1	0	0	0	0	0	14163.85012	256.6671
Jul-14	284	31	961	0	0	0	0	0	0	1	0	0	0	0	17787.11679	1850.792
Aug-14	292	32	1024	0	0	0	0	0	0	0	1	0	0	0	12933.31317	2603.125
Sep-14	425	33	1089	0	0	0	0	0	0	0	0	1	0	0	10729.04444	33863.67
Oct-14	336	34	1156	0	0	0	0	0	0	0	0	0	1	0	6035.343946	9028.959
Nov-14	230	35	1225	0	0	0	0	0	0	0	0	0	0	1	1623.594467	120.5421
Dec-14	341	36	1296	0	0	0	0	0	0	0	0	0	0	0	7123.39829	10004.17
Jan-15	202	37	1369	1	0	0	0	0	0	0	0	0	0	0	2756.737665	1519.375
Feb-15	264	38	1444	0	1	0	0	0	0	0	0	0	0	0	5940.366068	529.9588
Mar-15	404	39	1521	0	0	1	0	0	0	0	0	0	0	0	31645.88258	26575.79
Apr-15	561	40	1600	0	0	0	1	0	0	0	0	0	0	0	52652.81974	102413.3
May-15	459	41	1681	0	0	0	0	1	0	0	0	0	0	0	26335.17116	47533.08
Jun-15	481	42	1764	0	0	0	0	0	1	0	0	0	0	0	26114.64875	57610
Jul-15	471	43	1849	0	0	0	0	0	0	1	0	0	0	0	28957.62492	52909.58
Aug-15	388	44	1936	0	0	0	0	0	0	0	1	0	0	0	20949.24112	21615.13
Sep-15	190	45	2025	0	0	0	0	0	0	0	0	1	0	0	16591.41142	2598.875
Oct-15	370	46	2116	0	0	0	0	0	0	0	0	0	1	0	9433.611178	16646.38
Nov-15	315	47	2209	0	0	0	0	0	0	0	0	0	0	1	2910.160663	5479.084
Dec-15	397	48	2304	0	0	0	0	0	0	0	0	0	0	0	8512.835953	24342.5
Jan-16	296	49	2401	1	0	0	0	0	0	0	0	0	0	0	3275.047701	3325.444
Feb-16	465	50	2500	0	1	0	0	0	0	0	0	0	0	0	5777.506306	51377.78
Mar-16	367	51	2601	0	0	1	0	0	0	0	0	0	0	0	29255.29258	16555.11
Apr-16	278	52	2704	0	0	0	1	0	0	0	0	0	0	0	47012.50077	1573.444
May-16	197	53	2809	0	0	0	0	1	0	0	0	0	0	0	20694.41628	1708.444
Jun-16	235	54	2916	0	0	0	0	0	1	0	0	0	0	0	18875.30219	11.11111
Jul-16	118	55	3025	0	0	0	0	0	0	1	0	0	0	0	19647.43076	14480.11
Aug-16	160	56	3136	0	0	0	0	0	0	0	1	0	0	0	11870.35745	6136.111
Sep-16	263	57	3249	0	0	0	0	0	0	0	0	1	0	0	7609.604454	608.4444
Oct-16	218	58	3364	0	0	0	0	0	0	0	0	0	1	0	2476.54762	413.4444
Nov-16	136	59	3481	0	0	0	0	0	0	0	0	0	0	1	0.634890849	10472.11
Dec-16	127	60	3600	0	0	0	0	0	0	0	0	0	0	0	1110.800722	12395.11

Appendix E. Trigonometry Sample (1-year cycle)

Month	# of SDRs	X	X^2	Sin (2πt/L)	Cos (2πt/L)	Sin (4πt/L)	Cos (4πt/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	-0.8660254	0.5	1	-120.8719	-150.872	502.9064743	-2.91729	130936.225	44512.20877
Feb-12	4	2	4	0.5	0.866025404	-0.5	0.8660254		-83.51859	-87.5186	2187.964753	2.15564	105298.7941	56159.12543
Mar-12	1	3	9	0.8660254	0.5	-0.13983806	0.99017439		9.6225607	8.622561	862.2560724	83.5225	53525.87911	57590.00043
Apr-12	2	4	16	1	6.12574E-17	0	1		85.522535	83.52253	4176.12674	42.0801	24166.76439	57111.0421
May-12	4	5	25	0.8660254	-0.5	-0.13983806	0.99017439		88.160165	84.16016	2104.004123	15.4237	23353.6473	56159.12543
Jun-12	1	6	36	0.5	-0.8660254	-0.5	0.8660254		62.694991	61.69499	6169.499087	71.2047	31785.24734	57590.00043
Jul-12	3	7	49	1.225E-16	-1	-0.8660254	0.5		74.204725	71.20472	2373.490832	31.2306	27813.71441	56634.08377
Aug-12	2	8	64	-0.5	-0.8660254	-1	2.833E-16		95.691758	93.69176	4684.587912	27.9322	21108.43105	57111.0421
Sep-12	23	9	81	-0.8660254	-0.5	-0.9274352	-0.37398388		78.864414	55.86441	242.888756	2.43669	26281.19307	47514.9171
Oct-12	1	10	100	-1	-1.8377E-16	-0.8660254	-0.5		57.043842	56.04384	5604.384156	68.5376	33832.20382	57590.00043
Nov-12	2	11	121	-0.8660254	0.5	-0.9274352	-0.37398388		70.537608	68.53761	3426.880411	26.4499	29050.32485	57111.0421
Dec-12	37	12	144	-0.5	0.866025404	-1	-6.0488E-16		89.899774	52.89977	142.972363	0.58812	22824.9828	41607.50043
Jan-13	68	13	169	-2.45E-16	1	-0.8660254	0.5		89.760453	21.76045	32.00066656	0.1812	22867.09928	29921.7921
Feb-13	109	14	196	0.5	0.866025404	-0.5	0.8660254		121.32169	12.32169	11.30429933	-0.45256	14317.91262	17418.50043
Mar-13	258	15	225	0.8660254	0.5	-0.13983806	0.99017439		208.67072	-49.3293	19.11987678	-0.559	1043.835861	289.7087674
Apr-13	423	16	256	1	1.19447E-15	0	1		278.77857	-144.221	34.09490004	-0.21602	1428.795106	33131.58377
May-13	367	17	289	0.8660254	-0.5	-0.13983806	0.99017439		275.62408	-91.3759	24.89806982	-0.25513	1200.27028	15881.25043
Jun-13	338	18	324	0.5	-0.8660254	-0.5	0.8660254		244.36679	-93.6332	27.70213298	-0.40803	11.47599548	9413.042101
Jul-13	388	19	361	3.675E-16	-1	-0.8660254	0.5		250.08441	-137.916	35.54525633	-0.3382	82.90537301	21615.12543
Aug-13	397	20	400	-0.5	-0.8660254	-1	9.4944E-16		265.77932	-131.221	33.05306812	-0.42529	615.0475832	24342.50043
Sep-13	412	21	441	-0.8660254	-0.5	-0.9274352	-0.37398388		243.15986	-168.84	40.98061747	-0.08605	4.755406062	29248.12543
Oct-13	251	22	484	-1	-4.288E-16	-0.8660254	-0.5		215.54716	-35.4528	14.12463565	-0.19821	646.7867335	100.4171007
Nov-13	273	23	529	-0.8660254	0.5	-0.9274352	-0.37398388		223.24881	-49.7512	18.22387839	0.01399	314.365477	1025.333767
Dec-13	233	24	576	-0.5	0.866025404	-1	-1.4931E-15		236.81886	3.818859	1.638995236	0.27419	17.30816071	63.66710069
Jan-14	167	25	625	-4.901E-16	1	-0.8660254	0.5		230.88742	63.88742	38.25593933	0.20154	101.8433773	5472.917101
Feb-14	223	26	676	0.5	0.866025404	-0.5	0.8660254		256.65653	33.65653	15.09261548	-0.16496	245.7798	323.250434
Mar-14	375	27	729	0.8660254	0.5	-0.13983806	0.99017439		338.21344	-36.7866	9.809748003	0.29208	9454.504881	17961.58377
Apr-14	293	28	784	1	5.51317E-16	0	1		402.52918	109.5292	37.38197294	0.6095	26098.40704	2706.167101
May-14	215	29	841	0.8660254	-0.5	-0.13983806	0.99017439		393.58257	178.5826	83.06166162	0.46294	23287.79946	674.9171007
Jun-14	257	30	900	0.5	-0.8660254	-0.5	0.8660254		356.53316	99.53316	38.72885606	0.28194	13352.72539	256.6671007
Jul-14	284	31	961	2.389E-15	-1	-0.8660254	0.5		356.45866	72.45866	25.5136112	0.26184	13335.51241	1850.792101
Aug-14	292	32	1024	-0.5	-0.8660254	-1	1.1715E-15		366.36145	74.36145	25.46625025	-0.29812	15720.71716	2603.125434
Sep-14	425	33	1089	-0.8660254	-0.5	-0.9274352	-0.37398388		337.94987	-87.0501	20.48238399	-0.07401	9403.316924	33863.6671
Oct-14	336	34	1156	-1	1.10253E-15	-0.8660254	-0.5		304.54506	-31.4549	9.361590073	0.22754	4040.622459	9028.958767
Nov-14	230	35	1225	-0.8660254	0.5	-0.9274352	-0.37398388		306.45459	76.45459	33.2411242	-0.11638	4287.030491	120.5421007
Dec-14	341	36	1296	-0.5	0.866025404	-1	6.1257E-17		314.23251	-26.7675	7.849702819	0.29475	5366.052806	10004.1671
Jan-15	202	37	1369	-7.351E-16	1	-0.8660254	0.5		302.50895	100.509	49.75690792	0.28953	3785.914729	1519.375434
Feb-15	264	38	1444	0.5	0.866025404	-0.5	0.8660254		322.48595	58.48595	22.15376843	-0.02178	6643.355509	529.9587674
Mar-15	404	39	1521	0.8660254	0.5	-0.13983806	0.99017439		398.25074	-5.74926	1.423083677	-0.25798	24734.34839	26575.7921
Apr-15	561	40	1600	1	2.5727E-15	0	1		456.77436	-104.226	18.57854572	-0.03024	46567.56482	102413.3338
May-15	459	41	1681	0.8660254	-0.5	-0.13983806	0.99017439		442.03563	-16.9644	3.695940941	-0.17823	40423.70188	47533.08377
Jun-15	481	42	1764	0.5	-0.8660254	-0.5	0.8660254		399.1941	-81.8059	17.00746372	-0.16148	25031.96497	57610.00043
Jul-15	471	43	1849	8.576E-16	-1	-0.8660254	0.5		393.32748	-77.6725	16.49098173	0.02004	23210.00737	52909.58377
Aug-15	388	44	1936	-0.5	-0.8660254	-1	1.6156E-15		397.43815	9.438152	2.432513355	0.44648	24479.41403	21615.12543
Sep-15	190	45	2025	-0.8660254	-0.5	-0.9274352	-0.37398388		363.23445	173.2344	91.17602628	-0.24191	14946.35429	2598.875434
Oct-15	370	46	2116	-1	8.57495E-16	-0.8660254	-0.5		324.03752	-45.9625	12.42229187	0.01393	6898.690071	16646.37543
Nov-15	315	47	2209	-0.8660254	0.5	-0.9274352	-0.37398388		320.15493	5.154929	1.63648546	-0.23765	6268.801372	5479.083767
Dec-15	397	48	2304	-0.5	0.866025404	-1	-6.0488E-16		322.14074	-74.8593	18.85623734	0.02173	6587.200622	24342.50043
Jan-16	296	49	2401	-9.801E-16	1	-0.8660254	0.5		304.62506	8.625059	2.913871348	-0.49389	4394.592917	3325.444444
Feb-16	465	50	2500	0.5	0.866025404	-0.5	0.8660254		318.80993	-146.19	31.43872373	0.04684	6476.483362	51377.77778
Mar-16	367	51	2601	0.8660254	0.5	-0.13983806	0.99017439		388.78261	21.78261	5.935315745	0.44554	22634.98448	16555.11111
Apr-16	278	52	2704	1	2.81773E-15	0	1		441.51411	163.5141	58.8180238	0.8057	41282.42645	1573.444444
May-16	197	53	2809	0.8660254	-0.5	-0.13983806	0.99017439		420.98326	223.9833	113.6970861	0.69721	33360.99555	1708.444444
Jun-16	235	54	2916	0.5	-0.8660254	-0.5	0.8660254		372.34961	137.3496	58.44664205	1.03273	17960.36209	11.11111111
Jul-16	118	55	3025	1.103E-15	-1	-0.8660254	0.5		360.69087	242.6909	205.6702256	1.68652	14971.36585	14480.11111
Aug-16	160	56	3136	-0.5	-0.8660254	-1	-1.4931E-15		359.00942	199.0094	124.3808892	0.35009	14562.71856	6136.111111
Sep-16	263	57	3249	-0.8660254	-0.5	-0.9274352	-0.37398388		319.0136	56.0136	21.29794742	0.21302	6509.305706	608.4444444
Oct-16	218	58	3364	-1	-2.9402E-15	-0.8660254	-0.5		274.02455	56.02455	25.69933609	0.58876	1273.863138	413.4444444
Nov-16	136	59	3481	-0.8660254	0.5	-0.9274352	-0.37398388		264.34984	128.3498	94.37488428	0.98194	676.8587558	10472.11111
Dec-16	127	60	3600	-0.5	0.866025404	-1	-6.0488E-16		260.54353	133.5435	105.1523874	-1.89747	493.2929252	12395.11111

Appendix F. Trigonometry Sample (2-year cycle)

Month	# of SDRs	X	X^2	Sin (2πt/L)	Cos (2πt/L)	Sin (4πt/L)	Cos (4πt/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	-0.5	0.8660254	2	-57.24292	-87.2429	290.8097186	-1.88481	88936.41033	44512.20877
Feb-12	4	2	4	0.258819	0.965925826	-0.37841322	0.92563677		-52.54438	-56.5444	1413.609537	-9.94537	86156.07332	56159.12543
Mar-12	1	3	9	0.5	0.866025404	-0.25881905	0.96592583		-38.78146	-39.7815	3978.146019	-21.5794	78266.00834	57590.00043
Apr-12	2	4	16	0.7071068	0.707106781	-0.1527581	0.98826361		-19.5794	-21.5794	1078.970082	-1.36792	67890.76752	57111.0421
May-12	4	5	25	0.8660254	0.5	-0.07009142	0.99754057		1.26417	-2.73583	68.39575071	4.97199	57463.27964	56159.12543
Jun-12	1	6	36	0.9659258	0.258819045	-0.01784025	0.99984085		20.887976	19.88798	1988.797642	34.7017	48440.13203	57590.00043
Jul-12	3	7	49	1	6.12574E-17	0	1		37.701719	34.70172	1156.723961	16.4191	41321.7208	56634.08377
Aug-12	2	8	64	0.9659258	-0.25881905	-0.01784025	0.99984085		51.257386	49.25739	2462.869285	19.5656	35994.35417	57111.0421
Sep-12	23	9	81	0.8660254	-0.5	-0.07009142	0.99754057		62.131167	39.13117	170.1355091	3.08838	31986.60695	47514.9171
Oct-12	1	10	100	0.7071068	-0.70710678	-0.1527581	0.98826361		72.032805	71.03281	7103.280528	81.9261	28542.87303	57590.00043
Nov-12	2	11	121	0.5	-0.8660254	-0.25881905	0.96592583		83.926147	81.92615	4096.307342	32.3438	24665.65103	57111.0421
Dec-12	37	12	144	0.258819	-0.96592583	-0.37841322	0.92563677		101.68752	64.68752	174.8311338	1.64842	19402.16297	41607.50043
Jan-13	68	13	169	1.225E-16	-1	-0.5	0.8660254		128.99165	60.99165	89.69360035	0.8625	12541.20428	29921.7921
Feb-13	109	14	196	-0.258819	-0.96592583	-0.61241835	0.79053385		167.64974	58.64974	53.80709733	-0.38385	5377.205389	17418.50043
Mar-13	258	15	225	-0.5	-0.8660254	-0.70710678	0.70710678		216.16012	-41.8399	16.2170079	-0.59563	615.9850962	289.7087674
Apr-13	423	16	256	-0.7071068	-0.70710678	-0.77948234	0.6264242		269.32634	-153.674	36.329471	-0.11271	803.5621037	33131.58377
May-13	367	17	289	-0.8660254	-0.5	-0.82884977	0.55947123		319.32464	-47.6754	12.99056136	0.05418	6138.013159	15881.25043
Jun-13	338	18	324	-0.9659258	-0.25881905	-0.85696745	0.51537053		357.8845	19.8845	5.882986762	-0.02736	13666.85585	9413.042101
Jul-13	388	19	361	-1	-1.8377E-16	-0.8660254	0.5		378.75365	-9.24635	2.38308043	-0.04491	18981.80769	21615.12543
Aug-13	397	20	400	-0.9659258	0.258819045	-0.85696745	0.51537053		379.57371	-17.4263	4.389494115	-0.1245	19208.44699	24342.50043
Sep-13	412	21	441	-0.8660254	0.5	-0.82884977	0.55947123		362.57489	-49.4251	11.99638654	0.20119	14785.51931	29248.12543
Oct-13	251	22	484	-0.7071068	0.707106781	-0.77948234	0.6264242		333.89	82.89	33.02390355	0.11429	8632.422565	100.4171007
Nov-13	273	23	529	-0.5	0.866025404	-0.70710678	0.70710678		301.687	28.687	10.50805939	0.14912	3685.441288	1025.333767
Dec-13	233	24	576	-0.258819	0.965925826	-0.61241835	0.79053385		273.71095	40.71095	17.47250947	0.37815	1071.369447	63.66710069
Jan-14	167	25	625	-2.45E-16	1	-0.5	0.8660254		255.10882	88.10882	52.75977172	0.1459	199.6470686	5472.917101
Feb-14	223	26	676	0.258819	0.965925826	-0.37841322	0.92563677		247.36541	24.36541	10.92619089	-0.56643	40.78404869	323.250434
Mar-14	375	27	729	0.5	0.866025404	-0.25881905	0.96592583		248.68638	-126.314	33.68363206	-0.10014	59.40113417	17961.58377
Apr-14	293	28	784	0.7071068	0.707106781	-0.1527581	0.98826361		255.44649	-37.5535	12.81689721	0.16672	209.3034783	2706.167101
May-14	215	29	841	0.8660254	0.5	-0.07009142	0.99754057		263.84812	48.84812	22.72005377	0.06526	522.9888256	674.9171007
Jun-14	257	30	900	0.9659258	0.258819045	-0.01784025	0.99984085		271.02997	14.02997	5.459134193	-0.03346	903.051074	256.6671007
Jul-14	284	31	961	1	1.19447E-15	0	1		275.40177	-8.59823	3.027545739	-0.05452	1184.915627	1850.792101
Aug-14	292	32	1024	0.9659258	-0.25881905	-0.01784025	0.99984085		276.51549	-15.4845	5.302914451	-0.51388	1262.830262	2603.125434
Sep-14	425	33	1089	0.8660254	-0.5	-0.07009142	0.99754057		274.94732	-150.053	35.306512	-0.14963	1153.835714	33863.6671
Oct-14	336	34	1156	0.7071068	-0.70710678	-0.1527581	0.98826361		272.40702	-63.593	18.92648362	0.12458	987.7096527	9028.958767
Nov-14	230	35	1225	0.5	-0.8660254	-0.25881905	0.96592583		271.85841	41.85841	18.19930845	-0.27749	953.5276332	120.5421007
Dec-14	341	36	1296	0.258819	-0.96592583	-0.37841322	0.92563677		277.17783	-63.8222	18.71617745	0.26405	1310.343581	10004.1671
Jan-15	202	37	1369	3.675E-16	-1	-0.5	0.8660254		292.04002	90.04002	44.57426557	0.26859	2607.210382	1519.375434
Feb-15	264	38	1444	-0.258819	-0.96592583	-0.61241835	0.79053385		318.25616	54.25616	20.55157467	-0.18816	5971.733256	529.9587674
Mar-15	404	39	1521	-0.5	-0.8660254	-0.70710678	0.70710678		354.32459	-49.6754	12.2958927	-0.41077	12847.18578	26575.7921
Apr-15	561	40	1600	-0.7071068	-0.70710678	-0.77948234	0.6264242		395.04886	-165.951	29.5813076	-0.04705	23737.47175	102413.3338
May-15	459	41	1681	-0.8660254	-0.5	-0.82884977	0.55947123		432.60522	-26.3948	5.750496882	-0.04853	36720.54405	47533.08377
Jun-15	481	42	1764	-0.9659258	-0.25881905	-0.85696745	0.51537053		458.72313	-22.2769	4.631366404	-0.008	47412.43252	57610.00043
Jul-15	471	43	1849	-1	-4.288E-16	-0.8660254	0.5		467.15033	-3.84967	0.817339045	0.14337	51153.39652	52909.58377
Aug-15	388	44	1936	-0.9659258	0.258819045	-0.85696745	0.51537053		455.52845	67.52845	17.40423875	0.60847	46031.39341	21615.12543
Sep-15	190	45	2025	-0.8660254	0.5	-0.82884977	0.55947123		426.08768	236.0877	124.2566728	0.07874	34265.16107	2598.875434
Oct-15	370	46	2116	-0.7071068	0.707106781	-0.77948234	0.6264242		384.96084	14.96084	4.043470692	0.06842	20730.72271	16646.37543
Nov-15	315	47	2209	-0.5	0.866025404	-0.70710678	0.70710678		340.3159	25.3159	8.036793207	-0.30826	9867.786312	5479.083767
Dec-15	397	48	2304	-0.258819	0.965925826	-0.61241835	0.79053385		299.8979	-97.1021	24.45896818	-0.06838	3471.416706	24342.50043
Jan-16	296	49	2401	-4.901E-16	1	-0.5	0.8660254		268.85382	-27.1462	9.171006459	-0.73085	931.5001601	3325.444444
Feb-16	465	50	2500	0.258819	0.965925826	-0.37841322	0.92563677		248.66846	-216.332	46.5229117	-0.27839	106.8148558	51377.77778
Mar-16	367	51	2601	0.5	0.866025404	-0.25881905	0.96592583		237.54749	-129.453	35.27316416	-0.12571	0.617553597	16555.11111
Apr-16	278	52	2704	0.7071068	0.707106781	-0.1527581	0.98826361		231.86565	-46.1343	16.5950893	0.11088	41.83090504	1573.444444
May-16	197	53	2809	0.8660254	0.5	-0.07009142	0.99754057		227.82533	30.82533	15.64737513	-0.06312	110.4181549	1708.444444
Jun-16	235	54	2916	0.9659258	0.258819045	-0.01784025	0.99984085		222.56524	-12.4348	5.291386765	0.41062	248.6327326	11.11111111
Jul-16	118	55	3025	1	5.51317E-16	0	1		214.49509	96.49509	81.77549928	0.36582	568.2618856	14480.11111
Aug-16	160	56	3136	0.9659258	-0.25881905	-0.01784025	0.99984085		203.16686	43.16686	26.97928855	-0.46152	1236.680729	6136.111111
Sep-16	263	57	3249	0.8660254	-0.5	-0.07009142	0.99754057		189.15675	-73.8433	28.07728186	-0.16664	2418.336474	608.4444444
Oct-16	218	58	3364	0.7071068	-0.70710678	-0.1527581	0.98826361		174.17449	-43.8255	20.10344378	0.11552	4116.356851	413.4444444
Nov-16	136	59	3481	0.5	-0.8660254	-0.25881905	0.96592583		161.18394	25.18394	18.51760277	0.19898	5952.028927	10472.11111
Dec-16	127	60	3600	0.258819	-0.96592583	-0.37841322	0.92563677		154.06142	27.06142	21.3082032	-1.89747	7101.755703	12395.11111

Appendix G. Trigonometry Sample (3-year cycle)

Month	# of SDRs	X	X^2	Sin (2πt/L)	Cos (2πt/L)	Sin (4πt/L)	Cos (4πt/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	-0.34202014	0.93969262	3	-28.19217	-58.1922	193.9739043	0.08151	72453.20918	44512.20877
Feb-12	4	2	4	0.1736482	0.984807753	-0.28446776	0.95868561		6.4452994	2.445299	61.13248575	6.94194	55006.13488	56159.12543
Mar-12	1	3	9	0.3420201	0.939692621	-0.22766428	0.97373969		28.76775	27.76775	2776.774952	33.6984	45033.68557	57590.00043
Apr-12	2	4	16	0.5	0.866025404	-0.17364818	0.98480775		35.698423	33.69842	1684.92113	11.8924	42140.18389	57111.0421
May-12	4	5	25	0.6427876	0.766044443	-0.12436779	0.99223619		27.784787	23.78479	594.6196766	2.08132	45451.84349	56159.12543
Jun-12	1	6	36	0.7660444	0.64278761	-0.08157515	0.99666719		9.3252786	8.325279	832.5278646	-15.4503	53663.52384	57590.00043
Jul-12	3	7	49	0.8660254	0.5	-0.04674891	0.99890667		-12.45032	-15.4503	515.0106055	-10.3195	64226.50378	56634.08377
Aug-12	2	8	64	0.9396926	0.342020143	-0.02104969	0.99977843		-28.95845	-30.9585	1547.922504	-27.6081	72866.31693	57111.0421
Sep-12	23	9	81	0.9848078	0.173648178	-0.00530307	0.99998594		-32.21625	-55.2162	240.070638	-0.76963	74635.7339	47514.9171
Oct-12	1	10	100	1	6.12574E-17	0	1		-16.70143	-17.7014	1770.14321	17.3263	66399.29098	57590.00043
Nov-12	2	11	121	0.9848078	-0.17364818	-0.00530307	0.99998594		19.326324	17.32632	866.3162238	18.1777	49129.98245	57111.0421
Dec-12	37	12	144	0.9396926	-0.34202014	-0.02104969	0.99977843		73.355404	36.3554	98.25784879	1.92205	28097.72579	41607.50043
Jan-13	68	13	169	0.8660254	-0.5	-0.04674891	0.99890667		139.11568	71.11568	104.5818787	1.45474	10376.17043	29921.7921
Feb-13	109	14	196	0.7660444	-0.64278761	-0.08157515	0.99666719		207.92258	98.92258	90.75466031	0.11521	1092.737939	17418.50043
Mar-13	258	15	225	0.6427876	-0.76604444	-0.12436779	0.99223619		270.55834	12.55834	4.867574303	-0.40215	874.9275958	289.7087674
Apr-13	423	16	256	0.5	-0.8660254	-0.17364818	0.98480775		319.24571	-103.754	24.52820037	-0.04198	6125.652189	33131.58377
May-13	367	17	289	0.3420201	-0.93969262	-0.22766428	0.97373969		349.24217	-17.7578	4.838644797	0.05905	11720.87867	15881.25043
Jun-13	338	18	324	0.1736482	-0.98480775	-0.28446776	0.95868561		359.67305	21.67305	6.4121453	-0.10232	14088.23821	9413.042101
Jul-13	388	19	361	1.225E-16	-1	-0.34202014	0.93969262		353.41471	-34.5853	8.913733316	-0.15699	12641.75247	21615.12543
Aug-13	397	20	400	-0.1736482	-0.98480775	-0.39831629	0.91724813		336.08761	-60.9124	15.34317219	-0.24571	9045.61531	24342.50043
Sep-13	412	21	441	-0.3420201	-0.93969262	-0.45150685	0.89226765		314.45469	-97.5453	23.67604553	0.10601	5398.652883	29248.12543
Oct-13	251	22	484	-0.5	-0.8660254	-0.5	0.8660254		294.67425	43.67425	17.40009796	0.03139	2883.161531	100.4171007
Nov-13	273	23	529	-0.6427876	-0.76604444	-0.54252587	0.84003909		280.87987	7.879867	2.886398181	0.15183	1592.06589	1025.333767
Dec-13	233	24	576	-0.7660444	-0.64278761	-0.57815513	0.81592686		274.44927	41.44927	17.78938423	0.45971	1120.247499	63.66710069
Jan-14	167	25	625	-0.8660254	-0.5	-0.60627309	0.79525653		274.1135	107.1135	64.13981819	0.32225	1097.883805	5472.917101
Feb-14	223	26	676	-0.9396926	-0.34202014	-0.62652019	0.77940519		276.8159	53.8159	24.13269139	-0.43038	1284.271584	323.250434
Mar-14	375	27	729	-0.9848078	-0.17364818	-0.63871618	0.76944242		279.02601	-95.974	25.59306294	-0.03973	1447.562589	17961.58377
Apr-14	293	28	784	-1	-1.8377E-16	-0.64278761	0.76604444		278.10199	-14.898	5.084645994	0.19897	1378.103807	2706.167101
May-14	215	29	841	-0.9848078	0.173648178	-0.63871618	0.76944242		273.29912	58.29912	27.11587016	0.04248	1044.579438	674.9171007
Jun-14	257	30	900	-0.9396926	0.342020143	-0.62652019	0.77940519		266.1334	9.133404	3.553853635	-0.09341	632.7356478	256.6671007
Jul-14	284	31	961	-0.8660254	0.5	-0.60627309	0.79525653		259.99453	-24.0055	8.452628532	-0.11579	361.5842317	1850.792101
Aug-14	292	32	1024	-0.7660444	0.64278761	-0.57815513	0.81592686		259.11468	-32.8853	11.26209708	-0.54046	328.8967174	2603.125434
Sep-14	425	33	1089	-0.6427876	0.766044443	-0.54252587	0.84003909		267.1847	-157.815	37.1330111	-0.1176	686.7301257	33863.6671
Oct-14	336	34	1156	-0.5	0.866025404	-0.5	0.8660254		286.02102	-49.979	14.87469508	0.25205	2028.76896	9028.958767
Nov-14	230	35	1225	-0.3420201	0.939692621	-0.45150685	0.89226765		314.69001	84.69001	36.82174563	0.03646	5433.289153	120.5421007
Dec-14	341	36	1296	-0.1736482	0.984807753	-0.39831629	0.91724813		349.38528	8.385279	2.459026224	0.53416	11751.88528	10004.1671
Jan-15	202	37	1369	-2.45E-16	1	-0.34202014	0.93969262		384.14893	182.1489	90.17273836	0.73409	20497.58156	1519.375434
Feb-15	264	38	1444	0.1736482	0.984807753	-0.28446776	0.95868561		412.28548	148.2855	56.16874388	0.09131	29345.8543	529.9587674
Mar-15	404	39	1521	0.3420201	0.939692621	-0.22766428	0.97373969		428.10702	24.10702	5.967083053	-0.32788	35016.83182	26575.7921
Apr-15	561	40	1600	0.5	0.866025404	-0.17364818	0.98480775		428.53677	-132.463	23.61198392	-0.08	35177.85466	102413.3338
May-15	459	41	1681	0.6427876	0.766044443	-0.12436779	0.99223619		414.12222	-44.8778	9.777294921	-0.20008	29978.51564	47533.08377
Jun-15	481	42	1764	0.7660444	0.64278761	-0.08157515	0.99666719		389.16179	-91.8382	19.09318305	-0.22893	21958.08971	57610.00043
Jul-15	471	43	1849	0.8660254	0.5	-0.04674891	0.99890667		360.88527	-110.115	23.37892265	-0.10642	14377.47465	52909.58377
Aug-15	388	44	1936	0.9396926	0.342020143	-0.02104969	0.99977843		337.87622	-50.1238	12.91849896	0.35597	9389.039726	21615.12543
Sep-15	190	45	2025	0.9848078	0.173648178	-0.00530307	0.99998594		328.11751	138.1175	72.69342578	-0.17299	7593.090702	2598.875434
Oct-15	370	46	2116	1	3.06287E-16	0	1		337.13141	-32.8686	8.883403991	0.13962	9245.252981	16646.37543
Nov-15	315	47	2209	0.9848078	-0.17364818	-0.00530307	0.99998594		366.65824	51.65824	16.39944236	0.05456	15795.23034	5479.083767
Dec-15	397	48	2304	0.9396926	-0.34202014	-0.02104969	0.99977843		414.1864	17.1864	4.329069174	0.44697	30000.74728	24342.50043
Jan-16	296	49	2401	0.8660254	-0.5	-0.04674891	0.99890667		473.44576	177.4458	59.94789178	0.23903	55277.85302	3325.444444
Feb-16	465	50	2500	0.7660444	-0.64278761	-0.08157515	0.99666719		535.75174	70.75174	15.21542872	0.48363	88457.71073	51377.77778
Mar-16	367	51	2601	0.6427876	-0.76604444	-0.12436779	0.99223619		591.88659	224.8866	61.27699921	0.97023	124999.9033	16555.11111
Apr-16	278	52	2704	0.5	-0.8660254	-0.17364818	0.98480775		634.07304	356.073	128.0838272	1.65672	156609.915	1573.444444
May-16	197	53	2809	0.3420201	-0.93969262	-0.22766428	0.97373969		657.56858	460.5686	233.7911585	2.16497	175758.1939	1708.444444
Jun-16	235	54	2916	0.1736482	-0.98480775	-0.28446776	0.95868561		661.49854	426.4985	181.488741	2.25847	179068.7933	11.11111111
Jul-16	118	55	3025	3.675E-16	-1	-0.34202014	0.93969262		648.73929	530.7393	449.7790565	3.93993	168433.0465	14480.11111
Aug-16	160	56	3136	-0.1736482	-0.98480775	-0.39831629	0.91724813		624.91126	464.9113	290.5695374	2.08611	149442.4933	6136.111111
Sep-16	263	57	3249	-0.3420201	-0.93969262	-0.45150685	0.89226765		596.77743	333.7774	126.9115694	1.34029	128482.1687	608.4444444
Oct-16	218	58	3364	-0.5	-0.8660254	-0.5	0.8660254		570.49606	352.4961	161.6954416	1.9	110332.0787	413.4444444
Nov-16	136	59	3481	-0.6427876	-0.76604444	-0.54252587	0.84003909		550.20077	414.2008	304.5593863	3.01669	97261.29517	10472.11111
Dec-16	127	60	3600	-0.7660444	-0.64278761	-0.57815513	0.81592686		537.26925	410.2692	323.0466498	-1.89747	89362.67941	12395.11111

Appendix H. Trigonometry Sample (4-year cycle)

Month	# of SDRs	X	X^2	Sin (2πt/L)	Cos (2πt/L)	Sin (4πt/L)	Cos (4πt/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	-0.25881905	0.96592583	4	-33.47458	-63.4746	211.5819278	-1.17155	75324.85815	44512.20877
Feb-12	4	2	4	0.1305262	0.991444861	-0.22566707	0.97420448		-31.14637	-35.1464	878.6593327	-5.78144	74052.30951	56159.12543
Mar-12	1	3	9	0.258819	0.965925826	-0.19282535	0.98123309		-22.12576	-23.1258	2312.575579	-11.022	69224.20022	57590.00043
Apr-12	2	4	16	0.3826834	0.923879533	-0.16091049	0.986969		-9.022009	-11.022	551.1004437	0.97288	62500.58777	57111.0421
May-12	4	5	25	0.5	0.866025404	-0.13052619	0.99144486		5.9457523	1.945752	48.64380833	5.0496	55240.70585	56159.12543
Jun-12	1	6	36	0.6087614	0.79335334	-0.10224702	0.99475904		21.198393	20.19839	2019.83935	32.9252	48303.58825	57590.00043
Jul-12	3	7	49	0.7071068	0.707106781	-0.07660415	0.99706159		35.925161	32.92516	1097.50538	16.0255	42047.14508	56634.08377
Aug-12	2	8	64	0.7933533	0.608761429	-0.05407358	0.99853695		50.076566	48.07657	2403.828301	20.6147	36443.80293	57111.0421
Sep-12	23	9	81	0.8660254	0.5	-0.03506728	0.99938495		64.229498	41.2295	179.2586889	3.40662	31240.44522	47514.9171
Oct-12	1	10	100	0.9238795	0.382683432	-0.01992697	0.99980144		79.352318	78.35232	7835.231759	94.5127	26123.23834	57590.00043
Nov-12	2	11	121	0.9659258	0.258819045	-0.00892048	0.99996021		96.512669	94.51267	4725.633431	39.7894	20870.56906	57111.0421
Dec-12	37	12	144	0.9914449	0.130526192	-0.00223973	0.99999749		116.57873	79.57873	215.0776435	1.94499	15475.46912	41607.50043
Jan-13	68	13	169	1	6.12574E-17	0	1		139.96445	71.96445	105.8300719	0.84502	10203.97321	29921.7921
Feb-13	109	14	196	0.9914449	-0.13052619	-0.00223973	0.99999749		166.46147	57.46147	52.71694635	-0.57627	5552.88689	17418.50043
Mar-13	258	15	225	0.9659258	-0.25881905	-0.00892048	0.99996021		195.18605	-62.814	24.34649328	-0.7688	2097.009778	289.7087674
Apr-13	423	16	256	0.9238795	-0.38268343	-0.01992697	0.99980144		224.6508	-198.349	46.89106347	-0.26962	266.6155083	33131.58377
May-13	367	17	289	0.8660254	-0.5	-0.03506728	0.99938495		252.95119	-114.049	31.07597045	-0.16338	143.3293056	15881.25043
Jun-13	338	18	324	0.7933533	-0.60876143	-0.05407358	0.99853695		278.03798	-59.962	17.74024282	-0.26618	1373.355593	9413.042101
Jul-13	388	19	361	0.7071068	-0.70710678	-0.07660415	0.99706159		298.03281	-89.9672	23.18741961	-0.22027	3255.118438	21615.12543
Aug-13	397	20	400	0.6087614	-0.79335334	-0.10224702	0.99475904		311.53594	-85.4641	21.52747024	-0.23709	4978.25871	24342.50043
Sep-13	412	21	441	0.5	-0.8660254	-0.13052619	0.99144486		317.87524	-94.1248	22.8458153	0.16081	5913.006245	29248.12543
Oct-13	251	22	484	0.3826834	-0.92387953	-0.16091049	0.986969		317.25341	66.25341	26.39578245	0.15046	5817.760797	100.4171007
Nov-13	273	23	529	0.258819	-0.96592583	-0.19282535	0.98123309		310.76553	37.76553	13.83352852	0.24644	4870.136907	1025.333767
Dec-13	233	24	576	0.1305262	-0.99144486	-0.22566707	0.97420448		300.27891	67.27891	28.87506995	0.52013	3516.459913	63.66710069
Jan-14	167	25	625	1.225E-16	-1	-0.25881905	0.96592583		288.18932	121.1893	72.56845538	0.32388	2228.798623	5472.917101
Feb-14	223	26	676	-0.1305262	-0.99144486	-0.29166883	0.95651936		277.08771	54.08771	24.2545797	-0.4736	1303.827098	323.250434
Mar-14	375	27	729	-0.258819	-0.96592583	-0.3236249	0.94618546		269.38692	-105.613	28.16348742	-0.06943	807.0005721	17961.58377
Apr-14	293	28	784	-0.3826834	-0.92387953	-0.35413193	0.93519548		266.96522	-26.0348	8.885590454	0.19072	675.2749662	2706.167101
May-14	215	29	841	-0.5	-0.8660254	-0.38268343	0.92387953		270.88219	55.88219	25.99171582	0.11261	894.1907452	674.9171007
Jun-14	257	30	900	-0.6087614	-0.79335334	-0.408831	0.91261011		281.21198	24.21198	9.421003842	0.05067	1618.679259	256.6671007
Jul-14	284	31	961	-0.7071068	-0.70710678	-0.43218966	0.90178273		297.02151	13.02151	4.585038929	0.08627	3140.744309	1850.792101
Aug-14	292	32	1024	-0.7933533	-0.60876143	-0.45243938	0.89179516		316.49937	24.49937	8.390193994	-0.30062	5703.300577	2603.125434
Sep-14	425	33	1089	-0.8660254	-0.5	-0.46932332	0.8830264		337.21856	-87.7814	20.6544561	0.04823	9262.021135	33863.6671
Oct-14	336	34	1156	-0.9238795	-0.38268343	-0.48264345	0.87581693		356.49643	20.49643	6.100129244	0.42203	13344.23911	9028.958767
Nov-14	230	35	1225	-0.9659258	-0.25881905	-0.49225474	0.87045119		371.8007	141.8007	61.65247729	0.17454	17114.273	120.5421007
Dec-14	341	36	1296	-0.9914449	-0.13052619	-0.49805908	0.8671431		381.14399	40.14399	11.77242978	0.532	19646.17645	10004.1671
Jan-15	202	37	1369	-1	-1.8377E-16	-0.5	0.8660254		383.41087	181.4109	89.80735911	0.56718	20286.7888	1519.375434
Feb-15	264	38	1444	-0.9914449	0.130526192	-0.49805908	0.8671431		378.5708	114.5708	43.39803069	-0.13732	18931.45784	529.9587674
Mar-15	404	39	1521	-0.9659258	0.258819045	-0.49225474	0.87045119		367.74644	-36.2536	8.973654243	-0.51454	16069.94079	26575.7921
Apr-15	561	40	1600	-0.9238795	0.382683432	-0.48264345	0.87581693		353.12663	-207.873	37.05407718	-0.21616	12577.05287	102413.3338
May-15	459	41	1681	-0.8660254	0.5	-0.46932332	0.8830264		337.73511	-121.265	26.41936662	-0.33968	9361.712029	47533.08377
Jun-15	481	42	1764	-0.7933533	0.608761429	-0.45243938	0.89179516		325.08575	-155.914	32.41460546	-0.31648	7073.916978	57610.00043
Jul-15	471	43	1849	-0.7071068	0.707106781	-0.43218966	0.90178273		318.77121	-152.229	32.32033685	-0.14004	6051.602543	52909.58377
Aug-15	388	44	1936	-0.6087614	0.79335334	-0.408831	0.91261011		322.04134	-65.9587	16.99965398	0.37997	6571.076358	21615.12543
Sep-15	190	45	2025	-0.5	0.866025404	-0.38268343	0.92387953		337.42917	147.4292	77.59430085	-0.01855	9302.603453	2598.875434
Oct-15	370	46	2116	-0.3826834	0.923879533	-0.35413193	0.93519548		366.47583	-3.52417	0.952479107	0.25565	15749.41183	16646.37543
Nov-15	315	47	2209	-0.258819	0.965925826	-0.3236249	0.94618546		409.59122	94.59122	30.02895954	0.21926	28430.02539	5479.083767
Dec-15	397	48	2304	-0.1305262	0.991444861	-0.29166883	0.95651936		466.06757	69.06757	17.3973739	0.6001	50664.79129	24342.50043
Jan-16	296	49	2401	-2.45E-16	1	-0.25881905	0.96592583		534.24013	238.2401	80.48652991	0.49584	87560.83144	3325.444444
Feb-16	465	50	2500	0.1305262	0.991444861	-0.22566707	0.97420448		611.76763	146.7676	31.56293184	0.7075	139453.1762	51377.77778
Mar-16	367	51	2601	0.258819	0.965925826	-0.19282535	0.98123309		695.98755	328.9876	89.64238422	1.37954	209447.3821	16555.11111
Apr-16	278	52	2704	0.3826834	0.923879533	-0.16091049	0.986969		784.2906	506.2906	182.1189196	2.4369	298069.3332	1573.444444
May-16	197	53	2809	0.5	0.866025404	-0.13052619	0.99144486		874.45766	677.4577	343.8871356	3.70512	404654.1554	1708.444444
Jun-16	235	54	2916	0.6087614	0.79335334	-0.10224702	0.99475904		964.9096	729.9096	310.5998289	3.98653	527913.0682	11.11111111
Jul-16	118	55	3025	0.7071068	0.707106781	-0.07660415	0.99706159		1054.8357	936.8357	793.9285299	8.34056	666676.0581	14480.11111
Aug-16	160	56	3136	0.7933533	0.608761429	-0.05407358	0.99853695		1144.1864	984.1864	615.1164809	6.06587	820569.723	6136.111111
Sep-16	263	57	3249	0.8660254	0.5	-0.03506728	0.99938495		1233.5386	970.5386	369.0260842	4.20479	990433.5255	608.4444444
Oct-16	218	58	3364	0.9238795	0.382683432	-0.01992697	0.99980144		1323.8607	1105.861	507.2755596	5.87257	1178369.707	413.4444444
Nov-16	136	59	3481	0.9659258	0.258819045	-0.00892048	0.99996021		1416.2204	1280.22	941.3385077	10.18	1387417.872	10472.11111
Dec-16	127	60	3600	0.9914449	0.130526192	-0.00223973	0.99999749		1511.4857	1384.486	1090.146244	-1.89747	1620917.024	12395.11111

Appendix I. Autocorrelation Sample (1-year cycle)

Month	# of SDRs	X	X^2	SIN(2*PI*t/L)	COS(2*PI*t/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	1	N/A			0.4436232		
Feb-12	4	2	4	0.5	0.866025404		17.3087	13.3087	332.7173801	6.8800691	50028.47981	56159.12543
Mar-12	1	3	9	0.8660254	0.5		28.52028	27.52028	2752.027642	42.905801	45138.78005	57590.00043
Apr-12	2	4	16	1	6.12574E-17		44.9058	42.9058	2145.290067	24.864333	38444.76459	57111.0421
May-12	4	5	25	0.8660254	-0.5		53.72867	49.72867	1243.216633	13.104508	35062.75025	56159.12543
Jun-12	1	6	36	0.5	-0.8660254		53.41803	52.41803	5241.803081	40.318402	35179.17968	57590.00043
Jul-12	3	7	49	1.2251E-16	-1		43.3184	40.3184	1343.946738	10.412377	39069.77783	56634.08377
Aug-12	2	8	64	-0.5	-0.8660254		33.23713	31.23713	1561.856596	0.4697255	43156.753	57111.0421
Sep-12	23	9	81	-0.8660254	-0.5		23.93945	0.939451	4.084569412	1.4030333	47106.23819	47514.9171
Oct-12	1	10	100	-1	-1.8377E-16		33.26977	32.26977	3226.976555	26.701168	43143.19531	57590.00043
Nov-12	2	11	121	-0.8660254	0.5		28.70117	26.70117	1335.058378	4.3760646	45061.9489	57111.0421
Dec-12	37	12	144	-0.5	0.866025404		45.75213	8.752129	23.65440306	0.5343893	38113.59618	41607.50043
Jan-13	68	13	169	-2.45E-16	1		87.7724	19.7724	29.07706269	0.3068647	23472.31255	29921.7921
Feb-13	109	14	196	0.5	0.866025404		129.8668	20.8668	19.14385125	-0.7660258	12345.9585	17418.50043
Mar-13	258	15	225	0.8660254	0.5		174.5032	-83.4968	32.36310386	-0.5925741	4419.055201	289.7087674
Apr-13	423	16	256	1	1.19447E-15		270.1159	-152.884	36.14281464	-0.0055978	848.9488851	33131.58377
May-13	367	17	289	0.8660254	-0.5		364.6322	-2.36785	0.645190382	-0.0207359	15290.06061	15881.25043
Jun-13	338	18	324	0.5	-0.8660254		330.3899	-7.61009	2.251505349	-0.2496985	7994.281367	9413.042101
Jul-13	388	19	361	3.6754E-16	-1		303.6019	-84.3981	21.75208212	-0.20694	3921.609405	21615.12543
Aug-13	397	20	400	-0.5	-0.8660254		316.7073	-80.2927	20.22486433	-0.256625	5734.748452	24342.50043
Sep-13	412	21	441	-0.8660254	-0.5		310.1199	-101.88	24.72818104	0.1517934	4780.44019	29248.12543
Oct-13	251	22	484	-1	-4.288E-16		313.5389	62.53887	24.91588592	-0.1657701	5264.911078	100.4171007
Nov-13	273	23	529	-0.8660254	0.5		231.3917	-41.6083	15.24113112	0.0882063	91.91928622	1025.333767
Dec-13	233	24	576	-0.5	0.866025404		257.0803	24.08032	10.33490336	0.3820108	259.2472941	63.66710069
Jan-14	167	25	625	-4.901E-16	1		256.0085	89.00852	53.29851535	0.1206953	225.8814809	5472.917101
Feb-14	223	26	676	0.5	0.866025404		243.1561	20.15611	9.038613743	-0.3668294	4.739076381	323.250434
Mar-14	375	27	729	0.8660254	0.5		293.197	-81.803	21.81412107	0.2526615	2726.706922	17961.58377
Apr-14	293	28	784	1	5.51317E-16		387.7481	94.74808	32.33722699	0.4487707	21541.11248	2706.167101
May-14	215	29	841	0.8660254	-0.5		346.4898	131.4898	61.15805752	0.1893704	11132.49874	674.9171007
Jun-14	257	30	900	0.5	-0.8660254		297.7146	40.71463	15.84226761	0.0875753	3218.912546	256.6671007
Jul-14	284	31	961	2.3889E-15	-1		306.5069	22.50686	7.924949139	0.0441564	4293.878011	1850.792101
Aug-14	292	32	1024	-0.5	-0.8660254		304.5404	12.54041	4.29466265	-0.4461098	4040.032282	2603.125434
Sep-14	425	33	1089	-0.8660254	-0.5		294.7359	-130.264	30.65036656	0.0542615	2889.790906	33863.6671
Oct-14	336	34	1156	-1	1.10253E-15		359.0612	23.06115	6.863438428	0.2471222	13943.35552	9028.958767
Nov-14	230	35	1225	-0.8660254	0.5		313.0331	83.03306	36.10133096	-0.3214327	5191.763718	120.5421007
Dec-14	341	36	1296	-0.5	0.866025404		267.0705	-73.9295	21.68021257	0.4184369	680.756378	10004.1671
Jan-15	202	37	1369	-7.351E-16	1		344.687	142.687	70.63712709	0.1278228	10755.31402	1519.375434
Feb-15	264	38	1444	0.5	0.866025404		289.8202	25.82021	9.780382474	-0.2408484	2385.447488	529.9587674
Mar-15	404	39	1521	0.8660254	0.5		340.416	-63.584	15.73860689	-0.3345975	9887.689423	26575.7921
Apr-15	561	40	1600	1	2.5727E-15		425.8226	-135.177	24.0957907	0.0921063	34167.10008	102413.3338
May-15	459	41	1681	0.8660254	-0.5		510.6716	51.67161	11.25743064	-0.0756302	72734.01219	47533.08377
Jun-15	481	42	1764	0.5	-0.8660254		446.2858	-34.7142	7.217099469	-0.0610754	42150.7938	57610.00043
Jul-15	471	43	1849	8.576E-16	-1		441.6227	-29.3773	6.237213268	0.0616572	40257.8377	52909.58377
Aug-15	388	44	1936	-0.5	-0.8660254		417.0406	29.04056	7.484679956	0.4266041	30997.6136	21615.12543
Sep-15	190	45	2025	-0.8660254	-0.5		355.5224	165.5224	87.11704539	-0.6904759	13120.14915	2598.875434
Oct-15	370	46	2116	-1	8.57495E-16		238.8096	-131.19	35.4568714	0.0542007	4.707124421	16646.37543
Nov-15	315	47	2209	-0.8660254	0.5		335.0543	20.05427	6.366434322	-0.2638258	8850.124713	5479.083767
Dec-15	397	48	2304	-0.5	0.866025404		313.8949	-83.1051	20.93328122	0.1944748	5316.700311	24342.50043
Jan-16	296	49	2401	-9.801E-16	1		373.2065	77.20648	26.08327001	-0.5182971	18190.76548	3325.444444
Feb-16	465	50	2500	0.5	0.866025404		311.5841	-153.416	32.99267446	0.2088822	5365.669508	51377.77778
Mar-16	367	51	2601	0.8660254	0.5		464.1302	97.13023	26.46600384	0.2006765	50984.24039	16555.11111
Apr-16	278	52	2704	1	2.81773E-15		351.6483	73.64827	26.492184	0.636728	12840.27522	1573.444444
May-16	197	53	2809	0.8660254	-0.5		374.0104	177.0104	89.8529876	0.3880403	18408.2625	1708.444444
Jun-16	235	54	2916	0.5	-0.8660254		311.4439	76.44394	32.52933658	0.956326	5345.160947	11.11111111
Jul-16	118	55	3025	1.1026E-15	-1		342.7366	224.7366	190.4547563	0.5815133	10900.04468	14480.11111
Aug-16	160	56	3136	-0.5	-0.8660254		228.6186	68.61857	42.88660888	0.073981	94.37654487	6136.111111
Sep-16	263	57	3249	-0.8660254	-0.5		274.837	11.83697	4.500748008	0.2065005	1332.51529	608.4444444
Oct-16	218	58	3364	-1	-2.9402E-15		272.3096	54.30963	24.91267446	0.4226945	1154.388757	413.4444444
Nov-16	136	59	3481	-0.8660254	0.5		228.1474	92.14739	67.75543561	0.5521557	103.753392	10472.11111
Dec-16	127	60	3600	-0.5	0.866025404		202.0932	75.09318	59.12848801	-1.8974738	1313.34873	12395.11111

Appendix J. Autocorrelation Sample (2-year cycle)

Month	# of SDRs	X	X^2	SIN(2*PI*t/L)	COS(2*PI*t/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	2	N/A			-0.1953384		
Feb-12	4	2	4	0.25881905	0.965925826		-1.86015	-5.86015	146.5037751	-3.7903958	58970.93421	56159.12543
Mar-12	1	3	9	0.5	0.866025404		-14.1616	-15.1616	1516.158308	-16.71217	65096.80218	57590.00043
Apr-12	2	4	16	0.70710678	0.707106781		-14.7122	-16.7122	835.6085009	-7.505629	65378.05966	57111.0421
May-12	4	5	25	0.8660254	0.5		-11.0113	-15.0113	375.2814523	-1.2215792	63499.17417	56159.12543
Jun-12	1	6	36	0.96592583	0.258819045		-3.88632	-4.88632	488.631698	1.3227607	59959.10508	57590.00043
Jul-12	3	7	49	1	6.12574E-17		4.322761	1.322761	44.09202228	5.3002084	56006.2545	56634.08377
Aug-12	2	8	64	0.96592583	-0.25881905		17.90063	15.90063	795.0312593	5.0836968	49764.03567	57111.0421
Sep-12	23	9	81	0.8660254	-0.5		33.16739	10.16739	44.20605872	2.5817284	43185.73306	47514.9171
Oct-12	1	10	100	0.70710678	-0.70710678		60.37975	59.37975	5937.975269	68.983348	32616.14833	57590.00043
Nov-12	2	11	121	0.5	-0.8660254		70.98335	68.98335	3449.167391	27.744882	28898.57842	57111.0421
Dec-12	37	12	144	0.25881905	-0.96592583		92.48976	55.48976	149.9723344	1.6410396	22049.10279	41607.50043
Jan-13	68	13	169	1.2251E-16	-1		128.7185	60.71846	89.29185822	0.7857763	12602.46545	29921.7921
Feb-13	109	14	196	-0.258819	-0.96592583		162.4328	53.43279	49.02090645	-0.5436439	6169.533597	17418.50043
Mar-13	258	15	225	-0.5	-0.8660254		198.7428	-59.2572	22.96790161	-0.5585356	1783.9095	289.7087674
Apr-13	423	16	256	-0.7071068	-0.70710678		278.8978	-144.102	34.06671086	-0.0100079	1437.823743	33131.58377
May-13	367	17	289	-0.8660254	-0.5		362.7667	-4.23333	1.153496348	0.0277713	14832.19558	15881.25043
Jun-13	338	18	324	-0.9659258	-0.25881905		348.1921	10.19206	3.015403455	-0.1379974	11494.60529	9413.042101
Jul-13	388	19	361	-1	-1.8377E-16		341.3569	-46.6431	12.02142165	-0.0835544	10075.68614	21615.12543
Aug-13	397	20	400	-0.9659258	0.258819045		364.5809	-32.4191	8.166024671	-0.1143105	15277.38405	24342.50043
Sep-13	412	21	441	-0.8660254	0.5		366.6187	-45.3813	11.01487336	0.2842455	15785.2978	29248.12543
Oct-13	251	22	484	-0.7071068	0.707106781		368.1092	117.1092	46.6570326	0.0741754	16162.03313	100.4171007
Nov-13	273	23	529	-0.5	0.866025404		291.618	18.61802	6.819786933	0.2161268	2564.293297	1025.333767
Dec-13	233	24	576	-0.258819	0.965925826		292.0026	59.00263	25.32301638	0.420744	2603.393624	63.66710069
Jan-14	167	25	625	-2.45E-16	1		265.0334	98.03335	58.70260593	0.0244829	578.6038273	5472.917101
Feb-14	223	26	676	0.25881905	0.965925826		227.0886	4.088642	1.833471906	-0.5938424	192.9466658	323.250434
Mar-14	375	27	729	0.5	0.866025404		242.5732	-132.427	35.31382581	0.0216881	2.540793122	17961.58377
Apr-14	293	28	784	0.70710678	0.707106781		301.133	8.133048	2.775784392	0.1597879	3618.489472	2706.167101
May-14	215	29	841	0.8660254	0.5		261.8179	46.81786	21.77575015	-0.1385395	434.2512571	674.9171007
Jun-14	257	30	900	0.96592583	0.258819045		227.214	-29.786	11.5898769	-0.1426762	189.4793627	256.6671007
Jul-14	284	31	961	1	1.19447E-15		247.3322	-36.6678	12.91119162	-0.0977566	40.36123327	1850.792101
Aug-14	292	32	1024	0.96592583	-0.25881905		264.2371	-27.7629	9.507829931	-0.5103928	540.9331655	2603.125434
Sep-14	425	33	1089	0.8660254	-0.5		275.9653	-149.035	35.06698616	0.0184393	1224.030142	33863.6671
Oct-14	336	34	1156	0.70710678	-0.70710678		343.8367	7.836709	2.33235392	0.2627674	10579.67405	9028.958767
Nov-14	230	35	1225	0.5	-0.8660254		318.2899	88.28986	38.38689536	-0.2370361	5976.943199	120.5421007
Dec-14	341	36	1296	0.25881905	-0.96592583		286.4817	-54.5183	15.98777148	0.4279229	2070.480472	10004.1671
Jan-15	202	37	1369	3.6754E-16	-1		347.9217	145.9217	72.23847644	0.1845939	11436.71023	1519.375434
Feb-15	264	38	1444	-0.258819	-0.96592583		301.288	37.28796	14.12422901	-0.2454218	3637.151105	529.9587674
Mar-15	404	39	1521	-0.5	-0.8660254		339.2086	-64.7914	16.03746694	-0.3784624	9649.028169	26575.7921
Apr-15	561	40	1600	-0.7071068	-0.70710678		408.1012	-152.899	27.25469203	0.0394593	27929.76658	102413.3338
May-15	459	41	1681	-0.8660254	-0.5		481.1367	22.13668	4.822806384	-0.0905821	57675.63183	47533.08377
Jun-15	481	42	1764	-0.9659258	-0.25881905		439.4228	-41.5772	8.643908449	-0.0497477	39379.87575	57610.00043
Jul-15	471	43	1849	-1	-4.288E-16		447.0714	-23.9286	5.080390211	0.1043496	42473.99302	52909.58377
Aug-15	388	44	1936	-0.9659258	0.258819045		437.1486	49.14864	12.66717477	0.5214135	38482.46152	21615.12543
Sep-15	190	45	2025	-0.8660254	0.5		392.3085	202.3085	106.4781321	-0.3947402	22900.55228	2598.875434
Oct-15	370	46	2116	-0.7071068	0.707106781		294.9994	-75.0006	20.2704438	0.1146809	2918.181065	16646.37543
Nov-15	315	47	2209	-0.5	0.866025404		357.4319	42.43192	13.47044937	-0.2527776	13561.24271	5479.083767
Dec-15	397	48	2304	-0.258819	0.965925826		317.375	-79.625	20.05666307	0.0991331	5836.330628	24342.50043
Jan-16	296	49	2401	-4.901E-16	1		335.3558	39.35585	13.29589368	-0.6781927	9413.367825	3325.444444
Feb-16	465	50	2500	0.25881905	0.965925826		264.255	-200.745	43.17097453	-0.060621	671.9311662	51377.77778
Mar-16	367	51	2601	0.5	0.866025404		338.8112	-28.1888	7.680864384	-0.10767	10095.80726	16555.11111
Apr-16	278	52	2704	0.70710678	0.707106781		238.4851	-39.5149	14.21399453	0.0846704	0.023031669	1573.444444
May-16	197	53	2809	0.8660254	0.5		220.5384	23.53838	11.94841612	-0.3037501	316.6603726	1708.444444
Jun-16	235	54	2916	0.96592583	0.258819045		175.1612	-59.8388	25.46331003	0.3394573	3990.715721	11.11111111
Jul-16	118	55	3025	1	5.51317E-16		197.7725	79.77246	67.60377926	-0.2531036	1645.184484	14480.11111
Aug-16	160	56	3136	0.96592583	-0.25881905		130.1338	-29.8662	18.66638832	-0.5515156	11707.14363	6136.111111
Sep-16	263	57	3249	0.8660254	-0.5		174.7575	-88.2425	33.55228102	-0.0601994	4041.886467	608.4444444
Oct-16	218	58	3364	0.70710678	-0.70710678		202.1675	-15.8325	7.262592302	0.1896877	1307.963972	413.4444444
Nov-16	136	59	3481	0.5	-0.8660254		177.3519	41.35192	30.40582028	0.2556952	3718.733312	10472.11111
Dec-16	127	60	3600	0.25881905	-0.96592583		161.7745	34.77454	27.38153003	-1.8974738	5861.248356	12395.11111

Appendix K. Autocorrelation Sample (3-year cycle)

Month	# of SDRs	X	X^2	SIN(2*PI*t/L)	COS(2*PI*t/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	3	N/A			0.0610094		
Feb-12	4	2	4	0.17364818	0.984807753		5.830283	1.830283	45.75708197	-0.8110916	55294.99736	56159.12543
Mar-12	1	3	9	0.34202014	0.939692621		-2.24437	-3.24437	324.4366542	1.6394873	59157.68711	57590.00043
Apr-12	2	4	16	0.5	0.866025404		3.639487	1.639487	81.97436611	4.1460408	56330.12339	57111.0421
May-12	4	5	25	0.64278761	0.766044443		12.29208	8.292082	207.3020405	5.2221793	52297.78287	56159.12543
Jun-12	1	6	36	0.76604444	0.64278761		21.88872	20.88872	2088.871731	25.831362	48000.625	57590.00043
Jul-12	3	7	49	0.8660254	0.5		28.83136	25.83136	861.0453861	12.297158	45006.6912	56634.08377
Aug-12	2	8	64	0.93969262	0.342020143		38.89147	36.89147	1844.573647	12.138676	40839.43595	57111.0421
Sep-12	23	9	81	0.98480775	0.173648178		47.27735	24.27735	105.5537045	2.936538	37520.39299	47514.9171
Oct-12	1	10	100	1	6.12574E-17		68.54037	67.54037	6754.037329	62.458845	29735.13746	57590.00043
Nov-12	2	11	121	0.98480775	-0.17364818		64.45885	62.45885	3122.942251	18.310859	31159.42395	57111.0421
Dec-12	37	12	144	0.93969262	-0.34202014		73.62172	36.62172	98.97761508	0.9290084	28008.51576	41607.50043
Jan-13	68	13	169	0.8660254	-0.5		102.3733	34.37331	50.54898534	0.2843313	19211.58349	29921.7921
Feb-13	109	14	196	0.76604444	-0.64278761		128.3345	19.33453	17.73810216	-0.9025151	12688.81386	17418.50043
Mar-13	258	15	225	0.64278761	-0.76604444		159.6259	-98.3741	38.12951319	-0.6564621	6618.36116	289.7087674
Apr-13	423	16	256	0.5	-0.8660254		253.6328	-169.367	40.03953344	-0.0251729	160.1137669	33131.58377
May-13	367	17	289	0.34202014	-0.93969262		356.3519	-10.6481	2.901396284	-0.0251285	13310.86198	15881.25043
Jun-13	338	18	324	0.17364818	-0.98480775		328.7778	-9.22216	2.728450882	-0.2121398	7708.60634	9413.042101
Jul-13	388	19	361	1.2251E-16	-1		316.2967	-71.7033	18.48022086	-0.1227018	5672.737315	21615.12543
Aug-13	397	20	400	-0.1736482	-0.98480775		349.3917	-47.6083	11.99201526	-0.1367378	11753.27726	24342.50043
Sep-13	412	21	441	-0.3420201	-0.93969262		357.7151	-54.2849	13.17594836	0.286059	13627.27644	29248.12543
Oct-13	251	22	484	-0.5	-0.8660254		368.8563	117.8563	46.95469674	0.0125554	16352.55837	100.4171007
Nov-13	273	23	529	-0.6427876	-0.76604444		276.1514	3.15141	1.154362609	0.2093808	1237.086696	1025.333767
Dec-13	233	24	576	-0.7660444	-0.64278761		290.161	57.16096	24.53259951	0.4305257	2418.848485	63.66710069
Jan-14	167	25	625	-0.8660254	-0.5		267.3125	100.3125	60.06736256	0.0347668	693.4442059	5472.917101
Feb-14	223	26	676	-0.9396926	-0.34202014		228.806	5.806047	2.603608643	-0.508877	148.1848358	323.250434
Mar-14	375	27	729	-0.9848078	-0.17364818		261.5204	-113.48	30.26122009	0.1528478	421.9432795	17961.58377
Apr-14	293	28	784	-1	-1.8377E-16		350.3179	57.31792	19.56242889	0.2963047	11954.96225	2706.167101
May-14	215	29	841	-0.9848078	0.173648178		301.8173	86.81729	40.38013438	-0.0061586	3701.277118	674.9171007
Jun-14	257	30	900	-0.9396926	0.342020143		255.6759	-1.32411	0.515216476	-0.0155091	215.9937842	256.6671007
Jul-14	284	31	961	-0.8660254	0.5		280.0142	-3.98585	1.403468287	0.013292	1523.729929	1850.792101
Aug-14	292	32	1024	-0.7660444	0.64278761		295.7749	3.774931	1.292784563	-0.4256811	3002.57578	2603.125434
Sep-14	425	33	1089	-0.6427876	0.766044443		300.7011	-124.299	29.24679364	0.101884	3566.712547	33863.6671
Oct-14	336	34	1156	-0.5	0.866025404		379.3007	43.30069	12.88710921	0.2921884	19132.84297	9028.958767
Nov-14	230	35	1225	-0.3420201	0.939692621		328.1753	98.17529	42.68490699	-0.3192718	7603.163242	120.5421007
Dec-14	341	36	1296	-0.1736482	0.984807753		267.5675	-73.4325	21.53446275	0.3891654	706.9385143	10004.1671
Jan-15	202	37	1369	-2.45E-16	1		334.7054	132.7054	65.69573754	-0.0407116	8784.604908	1519.375434
Feb-15	264	38	1444	0.17364818	0.984807753		255.7763	-8.22375	3.115056685	-0.412102	218.9536856	529.9587674
Mar-15	404	39	1521	0.34202014	0.939692621		295.2051	-108.795	26.92943947	-0.4459384	2940.448001	26575.7921
Apr-15	561	40	1600	0.5	0.866025404		380.8409	-180.159	32.11392315	0.03185	19561.30196	102413.3338
May-15	459	41	1681	0.64278761	0.766044443		476.8678	17.86783	3.892774052	-0.1298664	55643.46286	47533.08377
Jun-15	481	42	1764	0.76604444	0.64278761		421.3913	-59.6087	12.39265687	-0.0667397	32548.54523	57610.00043
Jul-15	471	43	1849	0.8660254	0.5		438.8982	-32.1018	6.815662872	0.1057923	39171.95479	52909.58377
Aug-15	388	44	1936	0.93969262	0.342020143		437.8282	49.82815	12.84230698	0.525877	38749.52267	21615.12543
Sep-15	190	45	2025	0.98480775	0.173648178		394.0403	204.0403	107.389624	-0.4589397	23427.7061	2598.875434
Oct-15	370	46	2116	1	3.06287E-16		282.8015	-87.1985	23.56717334	0.2109885	1749.104105	16646.37543
Nov-15	315	47	2209	0.98480775	-0.17364818		393.0658	78.06576	24.78278027	-0.1006361	23130.33122	5479.083767
Dec-15	397	48	2304	0.93969262	-0.34202014		365.2996	-31.7004	7.984978512	0.3060829	15455.57892	24342.50043
Jan-16	296	49	2401	0.8660254	-0.5		417.5149	121.5149	41.05232918	-0.3204025	32106.03182	3325.444444
Feb-16	465	50	2500	0.76604444	-0.64278761		370.1609	-94.8391	20.39551282	0.2989451	17378.49821	51377.77778
Mar-16	367	51	2601	0.64278761	-0.76604444		506.0095	139.0095	37.87723782	0.2689827	71650.51028	16555.11111
Apr-16	278	52	2704	0.5	-0.8660254		376.7166	98.71665	35.50958497	0.7547016	19149.94128	1573.444444
May-16	197	53	2809	0.34202014	-0.93969262		406.8071	209.8071	106.5010416	0.5666404	28383.39389	1708.444444
Jun-16	235	54	2916	0.17364818	-0.98480775		346.6282	111.6282	47.50134521	1.2320395	11727.76975	11.11111111
Jul-16	118	55	3025	3.6754E-16	-1		407.5293	289.5293	245.3638079	1.227618	28627.27289	14480.11111
Aug-16	160	56	3136	-0.1736482	-0.98480775		304.8589	144.8589	90.53683071	0.7912375	4425.654896	6136.111111
Sep-16	263	57	3249	-0.3420201	-0.93969262		389.598	126.598	48.13612165	0.686336	22880.99936	608.4444444
Oct-16	218	58	3364	-0.5	-0.8660254		398.5064	180.5064	82.8010829	1.0433231	25655.3987	413.4444444
Nov-16	136	59	3481	-0.6427876	-0.76604444		363.4444	227.4444	167.2385545	1.4993678	15652.78755	10472.11111
Dec-16	127	60	3600	-0.7660444	-0.64278761		330.914	203.914	160.5622175	-1.8974738	8571.182834	12395.11111

Appendix L. Autocorrelation Sample (4-year cycle)

Month	# of SDRs	X	X^2	SIN(2*PI*t/L)	COS(2*PI*t/L)	L in Years	*Forecast*	Error	Percent Error	Theil's U	Explained Delta	Total Delta
Jan-12	30	1	1	0	1	4	N/A			0.2061518		
Feb-12	4	2	4	0.13052619	0.991444861		10.18456	6.184555	154.6138757	-0.0074693	53266.15276	56159.12543
Mar-12	1	3	9	0.25881905	0.965925826		0.970123	-0.02988	2.987739141	3.9753925	57604.34123	57590.00043
Apr-12	2	4	16	0.38268343	0.923879533		5.975393	3.975393	198.7696263	4.8678221	55226.77386	57111.0421
May-12	4	5	25	0.5	0.866025404		13.73564	9.735644	243.3911028	5.3457905	51639.61854	56159.12543
Jun-12	1	6	36	0.60876143	0.79335334		22.38316	21.38316	2138.31622	25.245606	47784.21317	57590.00043
Jul-12	3	7	49	0.70710678	0.707106781		28.24561	25.24561	841.5202149	11.750005	45255.56764	56634.08377
Aug-12	2	8	64	0.79335334	0.608761429		37.25002	35.25002	1762.500793	10.759552	41505.56689	57111.0421
Sep-12	23	9	81	0.8660254	0.5		44.5191	21.5191	93.56132317	2.7817404	38596.55609	47514.9171
Oct-12	1	10	100	0.92387953	0.382683432		64.98003	63.98003	6398.002979	57.547695	30975.69618	57590.00043
Nov-12	2	11	121	0.96592583	0.258819045		59.54769	57.54769	2877.384749	15.379198	32917.37892	57111.0421
Dec-12	37	12	144	0.99144486	0.130526192		67.7584	30.7584	83.13080249	0.7606446	30005.43507	41607.50043
Jan-13	68	13	169	1	6.12574E-17		96.14385	28.14385	41.38801502	0.1887244	20977.26889	29921.7921
Feb-13	109	14	196	0.99144486	-0.13052619		121.8333	12.83326	11.77363438	-0.9617502	14195.74672	17418.50043
Mar-13	258	15	225	0.96592583	-0.25881905		153.1692	-104.831	40.63208036	-0.674754	7710.584508	289.7087674
Apr-13	423	16	256	0.92387953	-0.38268343		248.9135	-174.087	41.15520961	-0.0311879	62.95306403	33131.58377
May-13	367	17	289	0.8660254	-0.5		353.8075	-13.1925	3.594676948	-0.0338412	12730.24084	15881.25043
Jun-13	338	18	324	0.79335334	-0.60876143		325.5803	-12.4197	3.674475912	-0.2217734	7157.346925	9413.042101
Jul-13	388	19	361	0.70710678	-0.70710678		313.0406	-74.9594	19.31943446	-0.127891	5192.849351	21615.12543
Aug-13	397	20	400	0.60876143	-0.79335334		347.3783	-49.6217	12.49917038	-0.1396276	11320.77421	24342.50043
Sep-13	412	21	441	0.5	-0.8660254		356.5678	-55.4322	13.45440697	0.2859664	13360.74217	29248.12543
Oct-13	251	22	484	0.38268343	-0.92387953		368.8182	117.8182	46.93951025	0.0076281	16342.81096	100.4171007
Nov-13	273	23	529	0.25881905	-0.96592583		274.9146	1.914644	0.70133468	0.2100059	1151.6166	1025.333767
Dec-13	233	24	576	0.13052619	-0.99144486		290.3316	57.3316	24.60583664	0.4337525	2435.662613	63.66710069
Jan-14	167	25	625	1.2251E-16	-1		268.0643	101.0643	60.5175654	0.0404679	733.6063012	5472.917101
Feb-14	223	26	676	-0.1305262	-0.99144486		229.7581	6.758142	3.030556964	-0.4964893	125.9113939	323.250434
Mar-14	375	27	729	-0.258819	-0.96592583		264.2829	-110.717	29.52456369	0.1682408	543.0633418	17961.58377
Apr-14	293	28	784	-0.3826834	-0.92387953		356.0903	63.0903	21.53252629	0.3146553	13250.57349	2706.167101
May-14	215	29	841	-0.5	-0.8660254		307.194	92.19401	42.88093665	0.0162611	4384.405981	674.9171007
Jun-14	257	30	900	-0.6087614	-0.79335334		260.4961	3.496143	1.360366772	0.0065569	380.9123498	256.6671007
Jul-14	284	31	961	-0.7071068	-0.70710678		285.6851	1.685134	0.59335694	0.0345621	1998.623489	1850.792101
Aug-14	292	32	1024	-0.7933533	-0.60876143		301.8156	9.815647	3.361522966	-0.4056054	3701.077347	2603.125434
Sep-14	425	33	1089	-0.8660254	-0.5		306.5632	-118.437	27.86747956	0.118648	4301.266985	33863.6671
Oct-14	336	34	1156	-0.9238795	-0.38268343		386.4254	50.42541	15.00756346	0.3072233	21154.61064	9028.958767
Nov-14	230	35	1225	-0.9659258	-0.25881905		333.227	103.227	44.88131656	-0.3083851	8509.667937	120.5421007
Dec-14	341	36	1296	-0.9914449	-0.13052619		270.0714	-70.9286	20.80016535	0.3972516	846.3601445	10004.1671
Jan-15	202	37	1369	-1	-1.8377E-16		337.4628	135.4628	67.06078856	-0.0435745	9309.090131	1519.375434
Feb-15	264	38	1444	-0.9914449	0.130526192		255.198	-8.80204	3.334107798	-0.4166576	202.1739534	529.9587674
Mar-15	404	39	1521	-0.9659258	0.258819045		294.0024	-109.998	27.2271283	-0.4477456	2811.46345	26575.7921
Apr-15	561	40	1600	-0.9238795	0.382683432		380.1108	-180.889	32.24406918	0.0320126	19357.60357	102413.3338
May-15	459	41	1681	-0.8660254	0.5		476.9591	17.95908	3.912654368	-0.1351995	55686.52117	47533.08377
Jun-15	481	42	1764	-0.7933533	0.608761429		418.9434	-62.0566	12.90157857	-0.0728748	31671.27086	57610.00043
Jul-15	471	43	1849	-0.7071068	0.707106781		435.9472	-35.0528	7.442207496	0.0984405	38012.53507	52909.58377
Aug-15	388	44	1936	-0.6087614	0.79335334		434.3655	46.36545	11.94985943	0.5144333	37398.25636	21615.12543
Sep-15	190	45	2025	-0.5	0.866025404		389.6001	199.6001	105.0526932	-0.4924053	22088.18688	2598.875434
Oct-15	370	46	2116	-0.3826834	0.923879533		276.443	-93.557	25.28567712	0.2047412	1257.683096	16646.37543
Nov-15	315	47	2209	-0.258819	0.965925826		390.7543	75.75425	24.04896915	-0.1027861	22432.57643	5479.083767
Dec-15	397	48	2304	-0.1305262	0.991444861		364.6224	-32.3776	8.155575191	0.3155432	15287.64086	24342.50043
Jan-16	296	49	2401	-2.45E-16	1		421.2706	125.2706	42.32115984	-0.3016844	33466.05566	3325.444444
Feb-16	465	50	2500	0.13052619	0.991444861		375.7014	-89.2986	19.20399736	0.336741	18869.98912	51377.77778
Mar-16	367	51	2601	0.25881905	0.965925826		523.5846	156.5846	42.66609576	0.3224309	81368.26885	16555.11111
Apr-16	278	52	2704	0.38268343	0.923879533		396.3321	118.3321	42.56552037	0.8765439	24963.62501	1573.444444
May-16	197	53	2809	0.5	0.866025404		440.6792	243.6792	123.6950249	0.7755117	40943.84941	1708.444444
Jun-16	235	54	2916	0.60876143	0.79335334		387.7758	152.7758	65.01098165	1.4784258	22333.0529	11.11111111
Jul-16	118	55	3025	0.70710678	0.707106781		465.4301	347.4301	294.4322488	1.799277	51572.92034	14480.11111
Aug-16	160	56	3136	0.79335334	0.608761429		372.3147	212.3147	132.6966764	1.3408665	17951.00186	6136.111111
Sep-16	263	57	3249	0.8660254	0.5		477.5386	214.5386	81.57362509	1.0744682	57219.17586	608.4444444
Oct-16	218	58	3364	0.92387953	0.382683432		500.5851	282.5851	129.6262045	1.5971985	68776.00265	413.4444444
Nov-16	136	59	3481	0.96592583	0.258819045		484.1893	348.1893	256.0215242	2.5157011	60445.143	10472.11111
Dec-16	127	60	3600	0.99144486	0.130526192		469.1354	342.1354	269.3979153	-1.8974738	53269.57199	12395.11111

Appendix M. Decomposition Multiplicative Sample (12 month)

Month	Period	X	# of SDRs	12 Month Moving Average	CMAt =TRt*CLt	SNt*IRt = Yt/(TRt*CLt)	Ave SNt	Norm SNt	Deseasonalized Yt (Yt/SNt)	TRt	TRtSNt	CLtIRt	CLt	IRt	Forecast	Error	Percentage Error	Explained Delta	Total Delta	Theil's U
Jan-12	1	1	30				0.630592	0.676775	44.32787597	21.63625	14.64288	2.048778								0.619408
Feb-12	2	2	4				0.92258	0.990148	4.039801178	31.14175	30.83493	0.129723	0.732359	0.17713	22.58223	-18.5822	464.5557	47697.22	56159.13	0.540509
Mar-12	3	3	1				1.234098	1.324481	0.755012434	40.64725	53.83653	0.018575	0.058734	0.316252	3.162035	-2.16204	216.2035	56556.99	57590	0.553424
Apr-12	4	4	2				1.331583	1.429105	1.399477014	50.15275	71.67356	0.027904	0.035626	0.783262	2.553424	-0.55342	27.6712	56846.83	57111.04	-0.88794
May-12	5	5	4				1.034354	1.110109	3.603250569	59.65824	66.22714	0.060398	0.033583	1.798468	2.224116	1.775884	44.39711	57003.97	56159.13	0.487243
Jun-12	6	6	1				1.082337	1.161606	0.86087724	69.16374	80.341	0.012447	0.036706	0.339101	2.948972	-1.94897	194.8972	56658.37	57590	-1.00113
Jul-12	7	7	3	9.166666667	10.75	0.279069767	0.953319	1.023138	2.932154603	78.66924	80.48952	0.037272	0.024834	1.500846	1.998873	1.001127	33.37092	57111.58	56634.08	1.881423
Aug-12	8	8	2	12.33333333	16.70833333	0.119700748	0.852779	0.915235	2.185231486	88.17474	80.70059	0.024783	0.094724	0.261634	7.644269	-5.64427	282.2134	54445.17	57111.04	-7.02993
Sep-12	9	9	23	21.08333333	31.79166667	0.723460026	0.987743	1.060084	21.69639968	97.68024	103.5492	0.222117	0.086337	2.572669	8.940133	14.05987	61.12985	53842.11	47514.92	0.267463
Oct-12	10	10	1	42.5	60.04166667	0.016655101	0.717739	0.770305	1.298187038	107.1857	82.56571	0.012112	0.086618	0.139828	7.151647	-6.15165	615.1647	54675.31	57590	7.747802
Nov-12	11	11	2	77.58333333	92.70833333	0.021573034	0.623211	0.668854	2.990187886	116.6912	78.04943	0.025625	0.124893	0.205174	9.747802	-7.7478	387.3901	53467.94	57111.04	1.686711
Dec-12	12	12	37	107.8333333	121.875	0.303589744	0.81078	0.87016	42.52093591	126.1967	109.8113	0.336942	0.367662	0.916444	40.37342	-3.37342	9.117359	40242.66	41607.5	-0.31919
Jan-13	1	13	68	135.9166667	151.9583333	0.447491089	0.630592	0.676775	100.4765189	135.7022	91.83988	0.740419	0.611826	1.210179	56.19005	11.80995	17.36758	34147.02	29921.79	0.340585
Feb-13	2	14	109	168	184.4583333	0.590919358	0.92258	0.990148	110.0845821	145.2077	143.7771	0.758118	0.919199	0.824759	132.1598	-23.1598	21.24749	11841.66	17418.5	0.026575
Mar-13	3	15	258	200.9166667	217.125	1.188255613	1.234098	1.324481	194.7932079	154.7132	204.9148	1.25906	1.273196	0.988897	260.8967	-2.89666	1.122736	396.7065	289.7088	-0.13425
Apr-13	4	16	423	233.3333333	243.75	1.735384615	1.331583	1.429105	295.9893884	164.2187	234.6858	1.80241	1.654825	1.089184	388.364	34.63597	8.188172	21722.3	33131.58	-0.06315
May-13	5	17	367	254.1666667	265.4583333	1.382514519	1.034354	1.110109	330.5982397	173.7242	192.8528	1.903006	1.764486	1.078505	340.286	26.714	7.279018	9861.848	15881.25	0.134262
Jun-13	6	18	338	276.75	284.9166667	1.186311787	1.082337	1.161606	290.976507	183.2297	212.8407	1.588042	1.819549	0.872767	387.274	-49.274	14.5781	21402.18	9413.042	-0.03935
Jul-13	7	19	388	293.0833333	297.2083333	1.305481565	0.953319	1.023138	379.2253287	192.7352	197.1948	1.967598	1.900151	1.035495	374.6999	13.30015	3.427872	17881.22	21615.13	-0.07738
Aug-13	8	20	397	301.3333333	306.0833333	1.297032399	0.852779	0.915235	433.7684499	202.2407	185.0977	2.144813	1.982618	1.081808	366.9782	30.02179	7.562164	15875.76	24342.5	-0.01005
Sep-13	9	21	412	310.8333333	315.7083333	1.30500198	0.987743	1.060084	388.6485508	211.7462	224.4687	1.835445	1.817664	1.009782	408.0087	3.991308	0.968764	27898.86	29248.13	0.090837
Oct-13	10	22	251	320.5833333	315.1666667	0.796404019	0.717739	0.770305	325.8449465	221.2517	170.4313	1.472734	1.692323	0.870244	288.4247	-37.4247	14.91025	2251.082	100.4171	-0.1948
Nov-13	11	23	273	309.75	303.4166667	0.899752815	0.623211	0.668854	408.1606464	230.7572	154.3429	1.768788	1.451999	1.218174	224.1059	48.89413	17.90994	284.7081	1025.334	0.134729
Dec-13	12	24	233	297.0833333	293.7083333	0.793304015	0.81078	0.87016	267.7669748	240.2627	209.0669	1.114476	1.290405	0.863664	269.7809	-36.7809	15.7858	829.5404	63.6671	0.001748
Jan-14	1	25	167	290.3333333	286	0.583916084	0.630592	0.676775	246.7585095	249.7682	169.0369	0.98795	0.99036	0.997567	167.4073	-0.40731	0.243901	5412.817	5472.917	0.155792
Feb-14	2	26	223	281.6666667	277.2916667	0.804207363	0.92258	0.990148	225.2189157	259.2737	256.7193	0.868653	0.969998	0.89552	249.0172	-26.0172	11.66691	64.61026	323.2504	-0.2668
Mar-14	3	27	375	272.9166667	273.4583333	1.37132409	1.234098	1.324481	283.1296626	268.7792	355.9931	1.053391	0.886261	1.188579	315.5029	59.49709	15.86589	5553.789	17961.58	0.089397
Apr-14	4	28	293	274	277.5416667	1.055697343	1.331583	1.429105	205.0233825	278.2847	397.6981	0.73674	0.821034	0.897331	326.5238	-33.5238	11.44157	7317.885	2706.167	0.049063
May-14	5	29	215	281.0833333	279.2916667	0.769804565	1.034354	1.110109	193.6747181	287.7902	319.4784	0.672972	0.717968	0.937328	229.3754	-14.3754	6.686219	134.6481	674.9171	0.047829
Jun-14	6	30	257	277.5	282	0.911347518	1.082337	1.161606	221.2454506	297.2957	345.3404	0.744193	0.773971	0.961527	267.2833	-10.2833	4.001286	691.9076	256.6671	-0.02306
Jul-14	7	31	284	286.5	287.9583333	0.986253798	0.953319	1.023138	277.5773024	306.8012	313.9001	0.904747	0.885864	1.021315	278.0729	5.927103	2.087008	1375.945	1850.792	0.040074
Aug-14	8	32	292	289.4166667	291.125	1.003005582	0.852779	0.915235	319.0437969	316.3067	289.4949	1.008653	1.047966	0.962486	303.3809	-11.3809	3.897584	3893.982	2603.125	-0.05974
Sep-14	9	33	425	292.8333333	294.0416667	1.445373388	0.987743	1.060084	400.9117332	325.8122	345.3882	1.2305	1.179994	1.042802	407.5559	17.44406	4.104486	27747.82	33863.67	-0.07575
Oct-14	10	34	336	295.25	306.4166667	1.096546097	0.717739	0.770305	436.1908448	335.3177	258.2969	1.300829	1.17619	1.105969	303.8061	32.1939	9.581517	3947.224	9028.959	0.094344
Nov-14	11	35	230	317.5833333	327.75	0.701754386	0.623211	0.668854	343.8716069	344.8232	230.6365	0.99724	1.134685	0.87887	261.6996	-31.6996	13.78246	429.3384	120.5421	-0.17622
Dec-14	12	36	341	337.9166667	347.25	0.98200144	0.81078	0.87016	391.8821391	354.3287	308.3225	1.105985	0.974528	1.134893	300.4689	40.53115	11.88597	3539.022	10004.17	0.04319
Jan-15	1	37	202	356.5833333	364.375	0.554373928	0.630592	0.676775	298.4743648	363.8342	246.2339	0.820358	0.88017	0.932045	216.7277	-14.7277	7.290934	588.1342	1519.375	0.115142
Feb-15	2	38	264	372.1666667	376.1666667	0.701816571	0.92258	0.990148	266.6268777	373.3397	369.6614	0.714167	0.777086	0.919032	287.2586	-23.2586	8.810091	2141.79	529.9588	0.07761
Mar-15	3	39	404	380.1666667	370.375	1.090786365	1.234098	1.324481	305.0250232	382.8452	507.0713	0.796732	0.837139	0.951733	424.489	-20.489	5.071523	33675.84	26575.79	-0.08114
Apr-15	4	40	561	360.5833333	362	1.549723757	1.331583	1.429105	392.5533023	392.3507	560.7104	1.000516	0.942052	1.062061	528.2185	32.78154	5.843412	82506.41	102413.3	-0.01344
May-15	5	41	459	363.4166667	366.9583333	1.250823209	1.034354	1.110109	413.4730028	401.8562	446.104	1.028908	1.012012	1.016695	451.4628	7.537158	1.642082	44303.38	47533.08	0.037995
Jun-15	6	42	481	370.5	372.8333333	1.290120697	1.082337	1.161606	414.0819523	411.3617	477.8401	1.006613	1.04311	0.965011	498.4398	-17.4398	3.625728	66285.95	57610	-0.05848
Jul-15	7	43	471	375.1666667	379.0833333	1.242470873	0.953319	1.023138	460.3482727	420.8672	430.6054	1.093809	1.028488	1.063512	442.8723	28.12766	5.971902	40760.85	52909.58	-0.13069
Aug-15	8	44	388	383	391.375	0.991376557	0.852779	0.915235	423.9349083	430.3727	393.892	0.985041	0.828769	1.18856	326.4455	61.55451	15.86457	7304.492	21615.13	0.49635
Sep-15	9	45	190	399.75	398.2083333	0.477137177	0.987743	1.060084	179.2311278	439.8782	466.3077	0.407456	0.820453	0.496623	382.5837	-192.584	101.3598	20051.84	2598.875	-0.42753
Oct-15	10	46	370	396.6666667	384.875	0.961351088	0.717739	0.770305	480.3292041	449.3836	346.1625	1.068862	0.834204	1.281296	288.77	81.22996	21.95404	2283.968	16646.38	-0.00268
Nov-15	11	47	315	373.0833333	362.1666667	0.869765301	0.623211	0.668854	470.954592	458.8891	306.93	1.026293	1.023067	1.003153	314.01	0.990029	0.314295	5333.498	5479.084	-0.00285
Dec-15	12	48	397	351.25	341	1.164222874	0.81078	0.87016	456.2381502	468.3946	407.5781	0.974046	0.971842	1.002268	396.1016	0.89836	0.226287	24062.98	24342.5	0.02911
Jan-16	1	49	296	330.75	316.0416667	0.936585366	0.630592	0.676775	437.3683762	477.9001	323.4309	0.915188	0.950919	0.962424	307.5567	-11.5567	3.904284	4791.872	3325.444	-0.24686
Feb-16	2	50	465	301.3333333	291.8333333	1.593375214	0.92258	0.990148	469.6268869	487.4056	482.6036	0.963524	0.812112	1.186442	391.9281	73.07192	15.71439	23591.35	51377.78	0.109645
Mar-16	3	51	367	282.3333333	285.375	1.286027157	1.234098	1.324481	277.0895631	496.9111	658.1496	0.557624	0.635091	0.878022	417.9848	-50.9848	13.89232	32274.66	16555.11	0.087649
Apr-16	4	52	278	288.4166667	282.0833333	0.985524372	1.331583	1.429105	194.5273049	506.4166	723.7227	0.384125	0.428572	0.896291	310.1672	-32.1672	11.57095	5160.11	1573.444	0.055778
May-16	5	53	197	275.75	268.2916667	0.734275509	1.034354	1.110109	177.4600905	515.9221	572.7297	0.343967	0.371041	0.927032	212.5062	-15.5062	7.871189	667.0386	1708.444	-0.21738
Jun-16	6	54	235	260.8333333	249.5833333	0.941569282	1.082337	1.161606	202.3061514	525.4276	610.3398	0.385031	0.314866	1.222842	192.1752	42.82477	18.22331	2130.57	11.11111	0.213436
Jul-16	7	55	118	238.3333333			0.953319	1.023138	115.3314144	534.9331	547.3106	0.2156	0.307243	0.701723	168.1575	-50.1575	42.50636	4924.647	14480.11	0.029939
Aug-16	8	56	160				0.852779	0.915235	174.8185189	544.4386	498.2892	0.321099	0.328189	0.978397	163.5329	-3.53286	2.208036	5595.111	6136.111	-0.08853
Sep-16	9	57	263				0.987743	1.060084	248.0936137	553.9441	587.2271	0.447868	0.423746	1.056925	248.8351	14.16486	5.38588	110.2878	608.4444	-0.11101
Oct-16	10	58	218				0.717739	0.770305	283.0047743	563.4496	434.0281	0.502272	0.435008	1.154627	188.8056	29.19438	13.39192	2452.995	413.4444	0.025243
Nov-16	11	59	136				0.623211	0.668854	203.3327762	572.9551	383.2235	0.354884	0.369244	0.961111	141.5029	-5.50288	4.046234	9376.137	10472.11	2.687959
Dec-16	12	60	127				0.81078	0.87016	145.9502395	582.4606	506.8337	0.250575	0.971842	0.257835	492.5624	-365.562	287.8444	64632.43	12395.11	-1.89747

Appendix N. Decomposition Multiplicative Sample (4 month)

Month	Period	X	# of SDRs	4 Month Moving Average	CMAt =TRt*CLt	SNt*IRt = Yt/(TRt*CLt)	Ave SNt	Norm SNt	Deseasonalized Yt (Yt/SNt)	TRt	TRtSNt	CLtIRt	CLt	IRt	Forecast	Error	Percentage Error	Explained Delta	Total Delta	Theil's U
Jan-12	1	1	30				0.751201	0.819191	36.62151521	27.8966	22.85263	1.312759								0.443593
Feb-12	2	2	4				0.897982	0.979257	4.084730996	36.67899	35.91814	0.111364	0.481867	0.23111	17.30778	-13.3078	332.6944	50028.89	56159.13	0.386919
Mar-12	3	3	1	9.25	6	0.166666667	0.939146	1.024146	0.976422812	45.46138	46.55911	0.021478	0.054719	0.392515	2.547676	-1.54768	154.7676	56849.58	57590	0.281914
Apr-12	4	4	2	2.75	2.375	0.842105263	1.079686	1.177406	1.698648997	54.24377	63.86695	0.031315	0.035729	0.876457	2.281914	-0.28191	14.09572	56976.38	57111.04	-0.7765
May-12	5	5	4	2	2.25	1.777777778	1.069932	1.166769	3.428269413	63.02616	73.537	0.054394	0.033276	1.634658	2.446995	1.553005	38.82513	56897.6	56159.13	0.383702
Jun-12	6	6	1	2.5	2.5	0.4	0.904554	0.986423	1.013764119	71.80855	70.83359	0.014118	0.035785	0.394507	2.53481	-1.53481	153.481	56855.71	57590	-0.99656
Jul-12	7	7	3	2.5	4.875	0.615384615	0.878778	0.958314	3.13049718	80.59094	77.23145	0.038844	0.025941	1.497422	2.003443	0.996557	33.21856	57109.4	56634.08	1.158554
Aug-12	8	8	2	7.25	7.25	0.275862069	0.825438	0.900147	2.221859857	89.37333	80.44912	0.02486	0.068064	0.365253	5.475663	-3.47566	173.7832	55461.9	57111.04	-6.71192
Sep-12	9	9	23	7.25	7.125	3.228070175	1.5295	1.667931	13.78953752	98.15572	163.717	0.140486	0.058492	2.401798	9.576159	13.42384	58.36453	53547.35	47514.92	0.203928
Oct-12	10	10	1	7	11.375	0.087912088	0.846531	0.923148	1.083249752	106.9381	98.71972	0.01013	0.057641	0.175737	5.690337	-4.69034	469.0337	55360.83	57590	6.505043
Nov-12	11	11	2	15.75	21.375	0.093567251	0.710445	0.774745	2.58149347	115.7205	89.65392	0.022308	0.094865	0.235155	8.505043	-6.50504	325.2522	54044.22	57111.04	3.442901
Dec-12	12	12	37	27	40.5	0.913580247	1.080738	1.178554	31.39441574	124.5029	146.7333	0.252158	0.299085	0.843097	43.8858	-6.8858	18.61027	38845.79	41607.5	-0.2065
Jan-13	1	13	68	54	86	0.790697674	0.751201	0.819191	83.0087678	133.2853	109.1861	0.62279	0.552813	1.126583	60.35952	7.640477	11.236	32623.46	29921.79	0.494962
Feb-13	2	14	109	118	166.25	0.655639098	0.897982	0.979257	111.3089196	142.0677	139.1207	0.783492	1.025422	0.764068	142.6574	-33.6574	30.87837	9667.164	17418.5	-0.14453
Mar-13	3	15	258	214.5	251.875	1.024317618	0.939146	1.024146	251.9170856	150.8501	154.4926	1.669983	1.568016	1.06503	242.2468	15.75323	6.105905	1.606807	289.7088	-0.23397
Apr-13	4	16	423	289.25	317.875	1.330711758	1.079686	1.177406	359.264263	159.6325	187.9523	2.250571	1.929409	1.166456	362.6368	60.36323	14.27027	14800.57	33131.58	0.06952
May-13	5	17	367	346.5	362.75	1.011716058	1.069932	1.166769	314.5437186	168.4149	196.5013	1.867672	2.017326	0.925816	396.4071	-29.4071	8.012844	24157.85	15881.25	0.028132
Jun-13	6	18	338	379	375.75	0.899534265	0.904554	0.986423	342.6522722	177.1972	174.7914	1.933734	1.992802	0.970359	348.3246	-10.3246	3.05462	11523.05	9413.042	-0.02738
Jul-13	7	19	388	372.5	378.125	1.026115702	0.878778	0.958314	404.8776352	185.9796	178.2269	2.177	2.125079	1.024433	378.7463	9.253726	2.384981	18979.78	21615.13	-0.17147
Aug-13	8	20	397	383.75	372.875	1.064699966	0.825438	0.900147	441.0391816	194.762	175.3144	2.264503	1.88502	1.201315	330.4711	66.52889	16.75791	8008.808	24342.5	0.318673
Sep-13	9	21	412	362	347.625	1.185185185	1.5295	1.667931	247.0125852	203.5444	339.4981	1.213556	1.586204	0.765069	538.5132	-126.513	30.70709	88526.51	29248.13	0.03903
Oct-13	10	22	251	333.25	312.75	0.802557954	0.846531	0.923148	271.8956878	212.3268	196.0091	1.280553	1.362591	0.939792	267.0803	-16.0803	6.406478	681.267	100.4171	-0.23814
Nov-13	11	23	273	292.25	261.625	1.043478261	0.710445	0.774745	352.3738587	221.1092	171.3033	1.593664	1.244729	1.28033	213.2262	59.77376	21.89515	770.2247	1025.334	0.240788
Dec-13	12	24	233	231	227.5	1.024175824	1.080738	1.178554	197.6999694	229.8916	270.9396	0.85997	1.10259	0.779955	298.7352	-65.7352	28.21254	3335.76	63.6671	0.020128
Jan-14	1	25	167	224	236.75	0.705385428	0.751201	0.819191	203.859768	238.674	195.5195	0.854135	0.878121	0.972685	171.6898	-4.68979	2.808257	4801.018	5472.917	0.214073
Feb-14	2	26	223	249.5	257	0.86770428	0.897982	0.979257	227.723753	247.4564	242.3233	0.920258	1.067789	0.861835	258.7502	-35.7502	16.03146	315.8084	323.2504	-0.39176
Mar-14	3	27	375	264.5	270.5	1.386321627	0.939146	1.024146	366.1585547	256.2388	262.426	1.428974	1.096074	1.303721	287.6383	87.36167	23.29645	2177.077	17961.58	0.062128
Apr-14	4	28	293	276.5	280.75	1.043633126	1.079686	1.177406	248.8520781	265.0212	312.0376	0.938989	1.013654	0.926341	316.2982	-23.2982	7.951598	5672.954	2706.167	0.187161
May-14	5	29	215	285	273.625	0.785746916	1.069932	1.166769	184.2694809	273.8035	319.4656	0.672999	0.844655	0.796774	269.8381	-54.8381	25.50611	832.8398	674.9171	-0.06649
Jun-14	6	30	257	262.25	262.125	0.980448259	0.904554	0.986423	260.5373786	282.5859	278.7492	0.921976	0.870695	1.058896	242.7055	14.29447	5.562051	2.980328	256.6671	-0.0114
Jul-14	7	31	284	262	288.25	0.985255854	0.878778	0.958314	296.353733	291.3683	279.2224	1.01711	1.006616	1.010425	281.0698	2.930229	1.031771	1607.257	1850.792	-0.10135
Aug-14	8	32	292	314.5	324.375	0.900192678	0.825438	0.900147	324.3915391	300.1507	270.1797	1.080762	0.974223	1.109358	263.2152	28.7848	9.857809	494.4411	2603.125	0.339262
Sep-14	9	33	425	334.25	327.5	1.297709924	1.5295	1.667931	254.8066716	308.9331	515.2792	0.824796	1.017049	0.810969	524.0644	-99.0644	23.30927	80137.26	33863.67	-0.12816
Oct-14	10	34	336	320.75	326.875	1.02791587	0.846531	0.923148	363.9719167	317.7155	293.2985	1.145591	0.959882	1.19347	281.532	54.46796	16.2107	1644.535	9028.959	0.04769
Nov-14	11	35	230	333	305.125	0.753789431	0.710445	0.774745	296.8717491	326.4979	252.9527	0.909261	0.972608	0.934869	246.0239	-16.0239	6.966892	25.44885	120.5421	-0.05727
Dec-14	12	36	341	277.25	268.25	1.271202237	1.080738	1.178554	289.3377234	335.2803	395.1458	0.862973	0.82964	1.040178	327.8287	13.17134	3.862564	7542.834	10004.17	0.053355
Jan-15	1	37	202	259.25	281	0.71886121	0.751201	0.819191	246.5848691	344.0627	281.8529	0.716686	0.781237	0.917373	220.1939	-18.1939	9.006904	432.0254	1519.375	0.159314
Feb-15	2	38	264	302.75	330.25	0.799394398	0.897982	0.979257	269.5922458	352.8451	345.5259	0.764053	0.85719	0.891346	296.1814	-32.1814	12.18993	3047.287	529.9588	-0.06139
Mar-15	3	39	404	357.75	389.875	1.036229561	0.939146	1.024146	394.4748162	361.6275	370.3595	1.090832	1.047073	1.041792	387.7935	16.20651	4.011513	21554.44	26575.79	-0.15991
Apr-15	4	40	561	422	449.125	1.249095463	1.079686	1.177406	476.4710438	370.4099	436.1229	1.286335	1.138206	1.130142	496.3979	64.60215	11.51553	65238.71	102413.3	0.123099
May-15	5	41	459	476.25	484.625	0.947124065	1.069932	1.166769	393.3939151	379.1922	442.4299	1.037452	1.193541	0.869222	528.0583	-69.0583	15.04538	82414.42	47533.08	-0.066
Jun-15	6	42	481	493	471.375	1.020418987	0.904554	0.986423	487.6205412	387.9746	382.707	1.256836	1.177684	1.06721	450.7079	30.29209	6.297732	43986.15	57610	-0.04158
Jul-15	7	43	471	449.75	416.125	1.131871433	0.878778	0.958314	491.4880572	396.757	380.2179	1.238763	1.186161	1.044347	450.9995	20.00046	4.246382	44108.56	52909.58	-0.15812
Aug-15	8	44	388	382.5	368.625	1.05256019	0.825438	0.900147	431.0408122	405.5394	365.045	1.062883	0.858862	1.237548	313.5233	74.47674	19.19504	5262.645	21615.13	0.866968
Sep-15	9	45	190	354.75	335.25	0.566741238	1.5295	1.667931	113.9135709	414.3218	691.0603	0.27494	0.761704	0.360954	526.3835	-336.384	177.044	81455.64	2598.875	-0.46475
Oct-15	10	46	370	315.75	316.875	1.16765286	0.846531	0.923148	400.8024083	423.1042	390.5879	0.94729	0.721216	1.313463	281.698	88.30198	23.8654	1658.025	16646.38	-0.05159
Nov-15	11	47	315	318	331.25	0.950943396	0.710445	0.774745	406.5852215	431.8866	334.6021	0.941417	0.884374	1.064501	295.9133	19.08672	6.059275	3017.757	5479.084	0.119
Dec-15	12	48	397	344.5	356.375	1.113995089	1.080738	1.178554	336.8535959	440.669	519.352	0.764414	0.836591	0.913726	434.4849	-37.4849	9.442052	37444.49	24342.5	0.0596
Jan-16	1	49	296	368.25	374.75	0.789859907	0.751201	0.819191	361.3322834	449.4514	368.1863	0.803941	0.868205	0.92598	319.6614	-23.6614	7.993708	6614.25	3325.444	-0.2533
Feb-16	2	50	465	381.25	366.375	1.269191402	0.897982	0.979257	474.8499783	458.2338	448.7285	1.036261	0.869171	1.192241	390.022	74.97803	16.12431	23009.44	51377.78	-0.00073
Mar-16	3	51	367	351.5	339.125	1.08219683	0.939146	1.024146	358.3471722	467.0162	478.293	0.767312	0.766606	1.000921	366.6622	0.337802	0.092044	16468.3	16555.11	0.062714
Apr-16	4	52	278	326.75	298	0.932885906	1.079686	1.177406	236.1122106	475.7985	560.2082	0.496244	0.537329	0.923539	301.0159	-23.0159	8.279088	3929.1	1573.444	0.191355
May-16	5	53	197	269.25	238.125	0.827296588	1.069932	1.166769	168.8422686	484.5809	565.3942	0.348429	0.442517	0.78738	250.1968	-53.1968	27.00343	140.7409	1708.444	-0.30642
Jun-16	6	54	235	207	192.25	1.22236671	0.904554	0.986423	238.234568	493.3633	486.6648	0.482879	0.35884	1.345664	174.635	60.36496	25.68722	4057.473	11.11111	0.23231
Jul-16	7	55	118	177.5	185.75	0.63526245	0.878778	0.958314	123.1328891	502.1457	481.2134	0.245213	0.358662	0.68369	172.5929	-54.5929	46.26521	4321.798	14480.11	-0.19121
Aug-16	8	56	160	194	191.875	0.833876221	0.825438	0.900147	177.7487885	510.9281	459.9103	0.347894	0.298836	1.164164	137.4377	22.56228	14.10143	10179.93	6136.111	0.339381
Sep-16	9	57	263	189.75	192	1.369791667	1.5295	1.667931	157.6803639	519.7105	866.8414	0.3034	0.366043	0.828866	317.3009	-54.3009	20.64674	6235.882	608.4444	-0.16296
Oct-16	10	58	218	194.25	190.125	1.14661407	0.846531	0.923148	236.148446	528.4929	487.8772	0.446834	0.358987	1.244709	175.1414	42.85864	19.65993	3993.225	413.4444	-0.0059
Nov-16	11	59	136	186			0.710445	0.774745	175.541556	537.2753	416.2515	0.326726	0.323633	1.009555	134.7128	1.287189	0.946463	10737.21	10472.11	0.480282
Dec-16	12	60	127				1.080738	1.178554	107.7592108	546.0577	643.5582	0.19734	0.298836	0.660364	192.3183	-65.3183	51.43174	2117.382	12395.11	-1.89747

Appendix O. Decomposition Additive Sample (12 month)

Month	Period	X	# of SDRs	12 Month Moving Average	CMAt =TRt+CLt	SNt+IRt = Yt-(TRt+CLt)	Ave SNt	Norm SNt	Deseasonalized Yt (Yt-SNt)	TRt	TRt+SNt	CLt-IRt	CLt	IRt	Forecast	Error	Percentage Error	Explained Delta	Total Delta	Theil's U
Jan-12	1	1	30				-96.3438	-99.6233	129.6232639	28.58727	-71.036	101.036								0.228356
Feb-12	2	2	4				-17.1875	-20.467	24.46701389	37.62522	17.15821	-13.1582	-6.30751	-6.85069	10.85069	-6.85069	171.2674	52959.11	56159.13	4.384549
Mar-12	3	3	1				64.41667	61.13715	-60.13715278	46.66317	107.8003	-106.8	-89.2621	-17.5382	18.53819	-17.5382	1753.819	49479.99	57590	38.96528
Apr-12	4	4	2				97.40625	94.12674	-92.12673611	55.70113	149.8279	-147.828	-108.863	-38.9653	40.96528	-38.9653	1948.264	40005.56	57111.04	-17.3038
May-12	5	5	4				14.5	11.22049	-7.220486111	64.73908	75.95957	-71.9596	-106.567	34.60764	-30.6076	34.60764	865.191	73759.39	56159.13	0.715278
Jun-12	6	6	1				30.41667	27.13715	-26.13715278	73.77703	100.9142	-99.9142	-97.0531	-2.86111	3.861111	-2.86111	286.1111	56224.97	57590	11.21875
Jul-12	7	7	3	9.166666667	10.75	-7.75	42.75	39.47049	-36.47048611	82.81499	122.2855	-119.285	-108.067	-11.2188	14.21875	-11.2188	373.9583	51420.29	56634.08	1.50463
Aug-12	8	8	2	12.33333333	16.70833333	-14.70833333	18.42708	15.14757	-13.14756944	91.85294	107.0005	-105.001	-100.487	-4.51389	6.513889	-4.51389	225.6944	54973.97	57111.04	-4.86285
Sep-12	9	9	23	21.08333333	31.79166667	-8.791666667	2.5625	-0.71701	23.71701389	100.8909	100.1739	-77.1739	-86.8996	9.725694	13.27431	9.725694	42.28563	51849.5	47514.92	0.473883
Oct-12	10	10	1	42.5	60.04166667	-59.04166667	-27.125	-30.4045	31.40451389	109.9288	79.52433	-78.5243	-67.625	-10.8993	11.89931	-10.8993	1089.931	52477.58	57590	-15.9792
Nov-12	11	11	2	77.58333333	92.70833333	-90.70833333	-66.5104	-69.7899	71.78993056	118.9668	49.17687	-47.1769	-63.156	15.97917	-13.9792	15.97917	798.9583	65003.75	57111.04	18.48958
Dec-12	12	12	37	107.8333333	121.875	-84.875	-23.9583	-27.2378	64.23784722	128.0048	100.7669	-63.7669	-26.7877	-36.9792	73.97917	-36.9792	99.94369	27889	41607.5	-1.27515
Jan-13	1	13	68	135.9166667	151.9583333	-83.95833333	-96.3438	-99.6233	167.6232639	137.0427	37.41944	30.58056	-16.6	47.18056	20.81944	47.18056	69.38317	48470.3	29921.79	0.517412
Feb-13	2	14	109	168	184.4583333	-75.45833333	-17.1875	-20.467	129.4670139	146.0807	125.6136	-16.6136	18.57038	-35.184	144.184	-35.184	32.27892	9369.299	17418.5	0.197598
Mar-13	3	15	258	200.9166667	217.125	40.875	64.41667	61.13715	196.8628472	155.1186	216.2558	41.74424	63.28243	-21.5382	279.5382	-21.5382	8.348137	1486.799	289.7088	-0.13579
Apr-13	4	16	423	233.3333333	243.75	179.25	97.40625	94.12674	328.8732639	164.1566	258.2833	164.7167	129.682	35.03472	387.9653	35.03472	8.28244	21604.92	33131.58	-0.0566
May-13	5	17	367	254.1666667	265.4583333	101.5416667	14.5	11.22049	355.7795139	173.1945	184.415	182.585	158.644	23.94097	343.059	23.94097	6.523426	10420.3	15881.25	0.075008
Jun-13	6	18	338	276.75	284.9166667	53.08333333	30.41667	27.13715	310.8628472	182.2325	209.3696	128.6304	156.1582	-27.5278	365.5278	-27.5278	8.144313	15512.36	9413.042	-0.00428
Jul-13	7	19	388	293.0833333	297.2083333	90.79166667	42.75	39.47049	348.5295139	191.2704	230.7409	157.2591	155.8112	1.447917	386.5521	1.447917	0.373174	21191.47	21615.13	-0.00211
Aug-13	8	20	397	301.3333333	306.0833333	90.91666667	18.42708	15.14757	381.8524306	200.3084	215.4559	181.5441	180.7246	0.819444	396.1806	0.819444	0.206409	24087.47	24342.5	-0.13617
Sep-13	9	21	412	310.8333333	315.7083333	96.29166667	2.5625	-0.71701	412.7170139	209.3463	208.6293	203.3707	149.3117	54.05903	357.941	54.05903	13.12112	13680.06	29248.13	0.155904
Oct-13	10	22	251	320.5833333	315.1666667	-64.16666667	-27.125	-30.4045	281.4045139	218.3843	187.9798	63.02023	127.2529	-64.2326	315.2326	-64.2326	25.59069	5513.578	100.4171	-0.19115
Nov-13	11	23	273	309.75	303.4166667	-30.41666667	-66.5104	-69.7899	342.7899306	227.4222	157.6323	115.3677	67.38853	47.97917	225.0208	47.97917	17.57479	254.6684	1025.334	0.108593
Dec-13	12	24	233	297.0833333	293.7083333	-60.70833333	-23.9583	-27.2378	260.2378472	236.4602	209.2223	23.77766	53.42349	-29.6458	262.6458	-29.6458	12.72353	469.4444	63.6671	-0.04226
Jan-14	1	25	167	290.3333333	286	-119	-96.3438	-99.6233	266.6232639	245.4981	145.8749	21.12512	11.2779	9.847222	157.1528	9.847222	5.89654	7026.863	5472.917	0.186731
Feb-14	2	26	223	281.6666667	277.2916667	-54.29166667	-17.1875	-20.467	243.4670139	254.5361	234.0691	-11.0691	20.11495	-31.184	254.184	-31.184	13.98387	174.3684	323.2504	-0.27711
Mar-14	3	27	375	272.9166667	273.4583333	101.5416667	64.41667	61.13715	313.8628472	263.574	324.7112	50.2888	-11.5063	61.79514	313.2049	61.79514	16.4787	5216.551	17961.58	0.106574
Apr-14	4	28	293	274	277.5416667	15.45833333	97.40625	94.12674	198.8732639	272.612	366.7387	-73.7387	-33.7735	-39.9653	332.9653	-39.9653	13.64003	8461.445	2706.167	0.024092
May-14	5	29	215	281.0833333	279.2916667	-64.29166667	14.5	11.22049	203.7795139	281.65	292.8704	-77.8704	-70.8114	-7.05903	222.059	-7.05903	3.283269	357.9717	674.9171	-0.0177
Jun-14	6	30	257	277.5	282	-25	30.41667	27.13715	229.8628472	290.6879	317.8251	-60.8251	-64.6306	3.805556	253.1944	3.805556	1.480761	149.213	256.6671	0.0229
Jul-14	7	31	284	286.5	287.9583333	-3.958333333	42.75	39.47049	244.5295139	299.7259	339.1963	-55.1963	-49.3109	-5.88542	289.8854	-5.88542	2.07233	2391.821	1850.792	0.136786
Aug-14	8	32	292	289.4166667	291.125	0.875	18.42708	15.14757	276.8524306	308.7638	323.9114	-31.9114	6.935837	-38.8472	330.8472	-38.8472	13.30384	8076.267	2603.125	-0.23765
Sep-14	9	33	425	292.8333333	294.0416667	130.9583333	2.5625	-0.71701	425.7170139	317.8018	317.0848	107.9152	38.52288	69.39236	355.6076	69.39236	16.32761	13139.69	33863.67	-0.00573
Oct-14	10	34	336	295.25	306.4166667	29.58333333	-27.125	-30.4045	366.4045139	326.8397	296.4352	39.56479	37.13076	2.434028	333.566	2.434028	0.724413	8572.317	9028.959	0.133991
Nov-14	11	35	230	317.5833333	327.75	-97.75	-66.5104	-69.7899	299.7899306	335.8777	266.0877	-36.0877	8.933088	-45.0208	275.0208	-45.0208	19.57428	1158.835	120.5421	-0.19574
Dec-14	12	36	341	337.9166667	347.25	-6.25	-23.9583	-27.2378	368.2378472	344.9156	317.6778	23.32222	-21.6986	45.02083	295.9792	45.02083	13.20259	3025	10004.17	0.048346
Jan-15	1	37	202	356.5833333	364.375	-162.375	-96.3438	-99.6233	301.6232639	353.9536	254.3303	-52.3303	-35.8442	-16.4861	218.4861	-16.4861	8.161441	505.9375	1519.375	0.124673
Feb-15	2	38	264	372.1666667	376.1666667	-112.1666667	-17.1875	-20.467	284.4670139	362.9915	342.5245	-78.5245	-53.3405	-25.184	289.184	-25.184	9.539404	2323.709	529.9588	0.082847
Mar-15	3	39	404	380.1666667	370.375	33.625	64.41667	61.13715	342.8628472	372.0295	433.1666	-29.1666	-7.29511	-21.8715	425.8715	-21.8715	5.413744	34185.19	26575.79	-0.11807
Apr-15	4	40	561	360.5833333	362	199	97.40625	94.12674	466.8732639	381.0674	475.1942	85.80582	38.10443	47.70139	513.2986	47.70139	8.502921	74157.88	102413.3	0.01496
May-15	5	41	459	363.4166667	366.9583333	92.04166667	14.5	11.22049	447.7795139	390.1054	401.3259	57.67412	66.06648	-8.39236	467.3924	-8.39236	1.828401	51262.93	47533.08	-0.02064
Jun-15	6	42	481	370.5	372.8333333	108.1666667	30.41667	27.13715	453.8628472	399.1433	426.2805	54.7195	45.24728	9.472222	471.5278	9.472222	1.969277	53152.66	57610	-0.02519
Jul-15	7	43	471	375.1666667	379.0833333	91.91666667	42.75	39.47049	431.5295139	408.1813	447.6518	23.34821	11.23363	12.11458	458.8854	12.11458	2.572098	47483.13	52909.58	-0.08737
Aug-15	8	44	388	383	391.375	-3.375	18.42708	15.14757	372.8524306	417.2193	432.3668	-44.3668	-85.5196	41.15278	346.8472	41.15278	10.60639	11208.05	21615.13	0.336618
Sep-15	9	45	190	399.75	398.2083333	-208.2083333	2.5625	-0.71701	190.7170139	426.2572	425.5402	-235.54	-104.933	-130.608	320.6076	-130.608	68.74086	6340.694	2598.875	-0.39527
Oct-15	10	46	370	396.6666667	384.875	-14.875	-27.125	-30.4045	400.4045139	435.2952	404.8906	-34.8906	-109.991	75.10069	294.8993	75.10069	20.29748	2907.381	16646.38	0.049606
Nov-15	11	47	315	373.0833333	362.1666667	-47.16666667	-66.5104	-69.7899	384.7899306	444.3331	374.5432	-59.5432	-41.189	-18.3542	333.3542	-18.3542	5.82672	8533.141	5479.084	-0.07202
Dec-15	12	48	397	351.25	341	56	-23.9583	-27.2378	424.2378472	453.3711	426.1332	-29.1332	-51.8207	22.6875	374.3125	22.6875	5.714736	17777.78	24342.5	0.099461
Jan-16	1	49	296	330.75	316.0416667	-20.04166667	-96.3438	-99.6233	395.6232639	462.409	362.7858	-66.7858	-27.2996	-39.4861	335.4861	-39.4861	13.3399	9438.662	3325.444	-0.30343
Feb-16	2	50	465	301.3333333	291.8333333	173.1666667	-17.1875	-20.467	485.4670139	471.447	450.98	14.02004	-75.7959	89.81597	375.184	89.81597	19.31526	18728.11	51377.78	0.041301
Mar-16	3	51	367	282.3333333	285.375	81.625	64.41667	61.13715	305.8628472	480.4849	541.6221	-174.622	-155.417	-19.2049	386.2049	-19.2049	5.232932	21865.99	16555.11	0.11253
Apr-16	4	52	278	288.4166667	282.0833333	-4.083333333	97.40625	94.12674	183.8732639	489.5229	583.6496	-305.65	-264.351	-41.2986	319.2986	-41.2986	14.85562	6555.376	1573.444	0.024193
May-16	5	53	197	275.75	268.2916667	-71.29166667	14.5	11.22049	185.7795139	498.5608	509.7813	-312.781	-306.056	-6.72569	203.7257	-6.72569	3.414058	1197.689	1708.444	-0.2562
Jun-16	6	54	235	260.8333333	249.5833333	-14.58333333	30.41667	27.13715	207.8628472	507.5988	534.7359	-299.736	-350.208	50.47222	184.5278	50.47222	21.47754	2895.038	11.11111	0.277527
Jul-16	7	55	118	238.3333333			42.75	39.47049	78.52951389	516.6367	556.1072	-438.107	-372.888	-65.2188	183.2188	-65.2188	55.27013	3037.617	14480.11	0.148423
Aug-16	8	56	160				18.42708	15.14757	144.8524306	525.6747	540.8223	-380.822	-363.308	-17.5139	177.5139	-17.5139	10.94618	3699.005	6136.111	-0.27954
Sep-16	9	57	263				2.5625	-0.71701	263.7170139	534.7126	533.9956	-270.996	-315.721	44.72569	218.2743	44.72569	17.00597	402.3646	608.4444	-0.0346
Oct-16	10	58	218				-27.125	-30.4045	248.4045139	543.7506	513.3461	-295.346	-304.447	9.100694	208.8993	9.100694	4.17463	866.362	413.4444	-0.01367
Nov-16	11	59	136				-66.5104	-69.7899	205.7899306	552.7886	482.9986	-346.999	-349.978	2.979167	133.0208	2.979167	2.190564	11090.72	10472.11	2.615941
Dec-16	12	60	127				-23.9583	-27.2378	154.2378472	561.8265	534.5887	-407.589	-51.8207	-355.768	482.7679	-355.768	280.1322	59748.28	12395.11	-1.89747

Appendix P. Simple Exponential Smoothing Sample

Date	Time	SDRs	Smoothed Estimate	Pred Interval Low	Forecast	Pred Interval High	Error	Percentage Error	Explained Variation	Total Variation	Theil's U
	0		151.125								
12-Jan	1	30	46.47545		151.125		-121.125	403.75	8073.771	44512.21	1.415848
12-Feb	2	4	9.77752		46.47544957		-42.4754	1061.886239	37831.7	56159.13	2.19438
12-Mar	3	1	2.19392		9.777520144		-8.77752	877.7520144	53454.2	57590	0.19392
12-Apr	4	2	2.026377		2.193920252		-0.19392	9.696012588	57018.39	57111.04	-0.98681
12-May	5	4	3.731547		2.026377076		1.973623	49.3405731	57098.44	56159.13	0.682887
12-Jun	6	1	1.371546		3.731547369		-2.73155	273.1547369	56286.43	57590	-1.62845
12-Jul	7	3	2.778497		1.371545684		1.628454	54.28181055	57411.81	56634.08	0.259499
12-Aug	8	2	2.105891		2.77849728		-0.7785	38.924864	56739.56	57111.04	-10.4471
12-Sep	9	23	20.15798		2.105891374		20.89411	90.84395055	57060.44	47514.92	0.832956
12-Oct	10	1	3.605873		20.15797867		-19.158	1915.797867	48762	57590	1.605873
12-Nov	11	2	2.218431		3.605872541		-1.60587	80.29362706	56346.08	57111.04	-17.3908
12-Dec	12	37	32.269		2.218431142		34.78157	94.00424016	57006.69	41607.5	-0.9657
13-Jan	13	68	63.13986		32.26900323		35.731	52.54558348	43559.93	29921.79	-0.67441
13-Feb	14	109	102.7621		63.13986183		45.86014	42.07352125	31626.82	17418.5	-1.4242
13-Mar	15	258	236.8845		102.7620938		155.2379	60.1697311	19103.96	289.7088	-0.72138
13-Apr	16	423	397.6845		236.8845053		186.1155	43.99893492	16.76625	33131.58	0.07254
13-May	17	367	371.1737		397.6845288		-30.6845	8.360907034	24556.57	15881.25	0.090392
13-Jun	18	338	342.5123		371.1737165		-33.1737	9.814709014	16950.62	9413.042	-0.13458
13-Jul	19	388	381.8128		342.5122963		45.4877	11.72363497	10308.98	21615.13	-0.03914
13-Aug	20	397	394.9342		381.8127524		15.18725	3.825503179	19834.1	24342.5	-0.04299
13-Sep	21	412	409.6787		394.9342272		17.06577	4.142177868	23702.16	29248.13	0.385142
13-Oct	22	251	272.5835		409.6787098		-158.679	63.21860947	28459.54	100.4171	-0.00166
13-Nov	23	273	272.9433		272.5835136		0.416486	0.152559133	998.8347	1025.334	0.146313
13-Dec	24	233	238.4331		272.9433494		-39.9433	17.14306842	1021.709	63.6671	0.30658
14-Jan	25	167	176.7163		238.4331033		-71.4331	42.77431336	6.482439	5472.917	-0.27715
14-Feb	26	223	216.7045		176.7163467		46.28365	20.75500149	4129.71	323.2504	-0.70985
14-Mar	27	375	353.4686		216.7044871		158.2955	42.21213677	589.2601	17961.58	0.16125
14-Apr	28	293	301.225		353.468609		-60.4686	20.6377505	12653.87	2706.167	0.294283
14-May	29	215	226.7283		301.2249537		-86.225	40.10462963	3629.555	674.9171	-0.1408
14-Jun	30	257	252.8824		226.7283375		30.27166	11.77885701	203.0861	256.6671	-0.12108
14-Jul	31	284	279.7674		252.8824417		31.11756	10.95688673	141.688	1850.792	-0.04307
14-Aug	32	292	290.3361		279.7673828		12.23262	4.189252478	1504.526	2603.125	-0.46118
14-Sep	33	425	406.683		290.3361167		134.6639	31.68561961	2436.109	33863.67	0.166313
14-Oct	34	336	345.6143		406.6829885		-70.683	21.03660372	27457.76	9028.959	0.34409
14-Nov	35	230	245.7259		345.6143159		-115.614	50.26709387	10948.51	120.5421	-0.41424
14-Dec	36	341	328.0408		245.7258851		95.27411	27.93962314	22.53134	10004.17	0.369621
15-Jan	37	202	219.1441		328.0407936		-126.041	62.39643247	7579.727	1519.375	-0.22206
15-Feb	38	264	257.8987		219.1440969		44.8559	16.99087238	476.7703	529.9588	-0.55341
15-Mar	39	404	384.1273		257.89869		146.1013	36.16369058	286.2703	26575.79	-0.4378
15-Apr	40	561	536.9417		384.1272672		176.8727	31.52811637	20491.38	102413.3	0.138934
15-May	41	459	469.6017		536.9417313		-77.9417	16.98076936	87593.84	47533.08	-0.02483
15-Jun	42	481	479.4496		469.6016517		11.39835	2.369718978	52268.24	57610	0.017567
15-Jul	43	471	472.1493		479.4495941		-8.44959	1.793969027	56868.14	52909.58	0.178661
15-Aug	44	388	399.446		472.1493157		-84.1493	21.68796796	53439.64	21615.13	0.539809
15-Sep	45	190	218.4889		399.4460087		-209.446	110.2347414	25111.74	2598.875	-0.79743
15-Oct	46	370	349.3914		218.4888929		151.5111	40.94894786	505.8124	16646.38	0.09295
15-Nov	47	315	319.6779		349.3914254		-34.3914	10.91791281	11753.22	5479.084	-0.24547
15-Dec	48	397	386.4826		319.6779294		77.32207	19.4765921	6193.495	24342.5	0.227916
16-Jan	49	296	308.3075	159.485475	386.4826347	613.4798	-90.4826	30.56845766	21948.22	3325.444	-0.26526
16-Feb	50	465	443.6866	115.279112	386.4826347	657.6862	78.51737	16.88545491	21948.22	51377.78	0.041898
16-Mar	51	367	377.4309	77.3305841	386.4826347	695.6347	-19.4826	5.308619801	21948.22	16555.11	0.295593
16-Apr	52	278	291.5246	43.5560679	386.4826347	729.4092	-108.483	39.02253046	21948.22	1573.444	0.681592
16-May	53	197	209.8573	12.8219998	386.4826347	760.1433	-189.483	96.18407851	21948.22	1708.444	0.768947
16-Jun	54	235	231.5801	-15.5694887	386.4826347	788.5348	-151.483	64.4606956	21948.22	11.11111	1.142479
16-Jul	55	118	133.4492	-42.084221	386.4826347	815.0495	-268.483	227.5276565	21948.22	14480.11	1.919344
16-Aug	56	160	156.3886	-67.051476	386.4826347	840.0167	-226.483	141.5516467	21948.22	6136.111	0.771766
16-Sep	57	263	248.4987	-90.7142109	386.4826347	863.6795	-123.483	46.95157212	21948.22	608.4444	0.640618
16-Oct	58	218	222.1484	-113.257767	386.4826347	886.223	-168.483	77.28561223	21948.22	413.4444	1.149003
16-Nov	59	136	147.7179	-134.827359	386.4826347	907.7926	-250.483	184.1784078	21948.22	10472.11	1.907961
16-Dec	60	127	129.8181	-155.539274	386.4826347	928.5045	-259.483	204.3170352	21948.22	12395.11	

Appendix Q. Holt's Trend Sample

Date	Time	SDRs	Estimate	Growth	Low interval	Forecast	High Interval	Error	Error^2	Percentage Error	Explained Variation	Total Variation	Theil's U
	0		-90.0217	19.29174									
12-Jan	1	30	15.11586	19.29174		-70.73		100.73	10146.53	335.7667	97162.6	44512.21	1.013587
12-Feb	2	4	8.49311	19.29174		34.4076		-30.4076	924.6222	760.19	42671.81	56159.13	6.696212
12-Mar	3	1	4.957802	19.29174		27.78485		-26.7848	717.4281	2678.485	45451.82	57590	22.24954
12-Apr	4	2	5.287652	19.29174		24.24954		-22.2495	495.0421	1112.477	46971.73	57111.04	10.2897
12-May	5	4	7.040867	19.29174		24.57939		-20.5794	423.5114	514.4848	46828.86	56159.13	6.333151
12-Jun	6	1	4.743214	19.29174		26.33261		-25.3326	641.7409	2533.261	46073.15	57590	21.03495
12-Jul	7	3	6.108182	19.29174		24.03495		-21.035	442.4693	701.1651	47064.79	56634.08	7.799974
12-Aug	8	2	5.457636	19.29174		25.39992		-23.3999	547.5563	1169.996	46474.41	57111.04	0.874687
12-Sep	9	23	23.25849	19.29174		24.74937		-1.74937	3.060312	7.605977	46755.32	47514.92	1.806532
12-Oct	10	1	7.139575	19.29174		42.55023		-41.5502	1726.422	4155.023	39374.04	57590	24.43131
12-Nov	11	2	5.610037	19.29174		26.43131		-24.4313	596.8891	1221.566	46030.78	57111.04	-6.04911
12-Dec	12	37	35.21233	19.29174		24.90178		12.09822	146.367	32.6979	46689.44	41607.5	-0.36475
13-Jan	13	68	66.00581	19.29174		54.50407		13.49593	182.1401	19.84695	34772.96	29921.79	-0.34857
13-Feb	14	109	105.4977	19.29174		85.29754		23.70246	561.8064	21.74537	24236.77	17418.5	-1.22212
13-Mar	15	258	238.3164	19.29174		124.7894		133.2106	17745.06	51.63202	13500.06	289.7088	-0.64105
13-Apr	16	423	398.5613	19.29174		257.6082		165.3918	27354.45	39.09972	276.5241	33131.58	0.12022
13-May	17	367	374.5142	19.29174		417.853		-50.853	2586.027	13.8564	31284.35	15881.25	0.15206
13-Jun	18	338	346.246	19.29174		393.8059		-55.8059	3114.3	16.51063	23356.02	9413.042	-0.06646
13-Jul	19	388	384.6809	19.29174		365.5378		22.46223	504.5517	5.789234	15514.85	21615.13	0.017971
13-Aug	20	397	398.0303	19.29174		403.9727		-6.97266	48.61798	1.756337	26566.88	24342.5	0.013406
13-Sep	21	412	412.7864	19.29174		417.322		-5.32204	28.32409	1.291757	31096.81	29248.13	0.43951
13-Oct	22	251	277.7566	19.29174		432.0781		-181.078	32789.29	72.14268	36518.82	100.4171	0.09581
13-Nov	23	273	276.5534	19.29174		297.0483		-24.0483	578.3224	8.808914	3143.752	1025.334	0.230202
13-Dec	24	233	242.2862	19.29174		295.8452		-62.8452	3949.517	26.97218	3010.28	63.6671	0.405914
14-Jan	25	167	180.9751	19.29174		261.5779		-94.5779	8944.982	56.63348	424.3084	5472.917	-0.13613
14-Feb	26	223	219.6409	19.29174		200.2668		22.73317	516.7971	10.19425	1657.495	323.2504	-0.61017
14-Mar	27	375	354.8943	19.29174		238.9326		136.0674	18514.33	36.28463	4.188337	17961.58	0.216496
14-Apr	28	293	304.9963	19.29174		374.1861		-81.1861	6591.176	27.70855	17744.08	2706.167	0.372997
14-May	29	215	231.1487	19.29174		324.288		-109.288	11943.87	50.83163	6940.363	674.9171	-0.03051
14-Jun	30	257	256.0307	19.29174		250.4404		6.559569	43.02794	2.552361	89.51553	256.6671	-0.03376
14-Jul	31	284	282.7178	19.29174		275.3225		8.67752	75.29936	3.055465	1179.463	1850.792	0.035245
14-Aug	32	292	293.479	19.29174		302.0095		-10.0095	100.1906	3.42792	3724.705	2603.125	-0.38435
14-Sep	33	425	408.4167	19.29174		312.7708		112.2292	12595.4	26.40688	5154.035	33863.67	0.215785
14-Oct	34	336	349.5511	19.29174		427.7084		-91.7084	8410.439	27.29418	34867.82	9028.959	0.413223
14-Nov	35	230	250.5158	19.29174		368.8428		-138.843	19277.33	60.36645	16349.12	120.5421	-0.30953
14-Dec	36	341	330.4804	19.29174		269.8075		71.19247	5068.368	20.87756	831.0746	10004.17	0.433349
15-Jan	37	202	223.8352	19.29174		349.7721		-147.772	21836.61	73.15453	11835.91	1519.375	-0.10333
15-Feb	38	264	260.9157	19.29174		243.127		20.87305	435.6841	7.906458	4.612981	529.9588	-0.46891
15-Mar	39	404	385.7081	19.29174		280.2075		123.7925	15324.59	30.64171	1538.861	26575.79	-0.38614
15-Apr	40	561	537.949	19.29174		404.9998		156.0002	24336.06	27.80752	26902.78	102413.3	0.175117
15-May	41	459	473.5163	19.29174		557.2407		-98.2407	9651.241	21.40321	100021.4	47533.08	0.025726
15-Jun	42	481	482.7448	19.29174		492.8081		-11.8081	139.4302	2.454897	63417.79	57610	0.064525
15-Jul	43	471	475.586	19.29174		502.0365		-31.0365	963.2662	6.589497	68150.95	52909.58	0.226917
15-Aug	44	388	403.7926	19.29174		494.8778		-106.878	11422.86	27.54582	64464.51	21615.13	0.600733
15-Sep	45	190	224.4412	19.29174		423.0843		-233.084	54328.29	122.6759	33162.28	2598.875	-0.66456
15-Oct	46	370	351.3424	19.29174		243.7329		126.2671	15943.38	34.12624	7.583074	16646.38	0.150363
15-Nov	47	315	323.2207	19.29174		370.6342		-55.6342	3095.161	17.66164	16810.42	5479.084	-0.17298
15-Dec	48	397	388.9488	19.29174		342.5124		54.48761	2968.899	13.72484	10309	24342.5	0.282722
16-Jan	49	296	312.585	19.29174	235.1458	408.2405	581.3352	-112.241	12597.93	37.91909	28868.45	3325.444	-0.12658
16-Feb	50	465	445.3293	19.29174	254.4376	427.5322	600.6269	37.46776	1403.833	8.057582	35796.23	51377.78	0.171664
16-Mar	51	367	381.4248	19.29174	273.7293	446.824	619.9187	-79.824	6371.868	21.7504	43468.35	16555.11	0.512577
16-Apr	52	278	296.1329	19.29174	293.021	466.1157	639.2104	-188.116	35387.52	67.66753	51884.82	1573.444	1.037437
16-May	53	197	214.4987	19.29174	312.3128	485.4075	658.5021	-288.407	83178.86	146.3997	61045.62	1708.444	1.369031
16-Jun	54	235	234.8213	19.29174	331.6045	504.6992	677.7939	-269.699	72737.66	114.7656	70950.77	11.11111	1.727621
16-Jul	55	118	138.1124	19.29174	350.8963	523.9909	697.0856	-405.991	164828.6	344.0601	81600.27	14480.11	3.248158
16-Aug	56	160	159.6164	19.29174	370.188	543.2827	716.3774	-383.283	146905.6	239.5517	92994.1	6136.111	1.87234
16-Sep	57	263	250.5744	19.29174	389.4797	562.5744	735.6691	-299.574	89744.83	113.9066	105132.3	608.4444	1.383522
16-Oct	58	218	225.6639	19.29174	408.7715	581.8662	754.9608	-363.866	132398.6	166.9111	118014.8	413.4444	2.133752
16-Nov	59	136	152.0996	19.29174	428.0632	601.1579	774.2526	-465.158	216371.9	342.0279	131641.7	10472.11	3.628306
16-Dec	60	127	133.5594	19.29174	447.355	620.4496	793.5443	-493.45	243492.5	388.543	146012.9	12395.11	

Appendix R. Additive Holt-Winters Sample (4 month)

Date	Time	SDRs	Estimate	Growth	Seasonal	Forecast	Error	Regression Estimates	Detrended	Averages / Seasons L=4	Percentage Error	Explained Variation	Total Variation	Theil's U
	-3				-14.16275872					-14.16275872				
	-2				-16.95703068					-16.95703068				
	-1				4.915364018					4.915364018				
	0		23.47783688	8.877605297	26.20442539					26.20442539				
12-Jan	1	30	42.46531871	8.877605297	-14.16275872	18.19268346	11.81	32.35544218	-2.36	1	39.35772181	49633.8171	44512.20877	1.012863
12-Feb	2	4	25.32535865	8.877605297	-16.95703068	34.38589332	-30.39	41.23304747	-37.23	2	759.6473331	42680.78059	56159.12543	9.529582
12-Mar	3	1	1.564591972	8.877605297	4.915364018	39.11832797	-38.12	50.11065277	-49.11	3	3811.832797	40747.7982	57590.00043	34.64662
12-Apr	4	2	-19.22356769	8.877605297	26.20442539	36.64662266	-34.65	58.98825807	-56.99	4	1732.331133	41751.78854	57111.0421	-14.2544
12-May	5	4	14.06429624	8.877605297	-14.16275872	-24.50872111	28.51	67.86586337	-63.87	1	712.7180278	70483.81856	56159.12543	1.246218
12-Jun	6	1	18.67366424	8.877605297	-16.95703068	5.984870852	-4.98	76.74346866	-75.74	2	498.4870852	55222.31907	57590.00043	29.46663
12-Jul	7	3	2.320809594	8.877605297	4.915364018	32.46663356	-29.47	85.62107396	-82.62	3	982.2211185	43477.47646	56634.08377	11.80095
12-Aug	8	2	-19.11485255	8.877605297	26.20442539	37.40284028	-35.40	94.49867926	-92.50	4	1770.142014	41443.32067	57111.0421	-23.7
12-Sep	9	23	30.34845283	8.877605297	-14.16275872	-24.40000597	47.40	103.3762846	-80.38	1	206.0869825	70426.10527	47514.9171	0.92474
12-Oct	10	1	21.01470243	8.877605297	-16.95703068	22.26902745	-21.27	112.2538899	-111.25	2	2126.902745	47834.125	57590.00043	32.80767
12-Nov	11	2	1.801122955	8.877605297	4.915364018	34.80767174	-32.81	121.1314952	-119.13	3	1640.383587	42506.68532	57111.0421	-0.05842
12-Dec	12	37	10.77877658	8.877605297	26.20442539	36.88315364	0.12	130.0091004	-93.01	4	0.315800974	41655.18253	41607.50043	-1.68936
13-Jan	13	68	73.17673513	8.877605297	-14.16275872	5.493623157	62.51	138.8867057	-70.89	1	91.92114242	55453.4412	29921.7921	-0.64563
13-Feb	14	109	119.6455049	8.877605297	-16.95703068	65.09730975	43.90	147.764311	-38.76	2	40.27769748	30934.42759	17418.50043	-1.14277
13-Mar	15	258	235.1774581	8.877605297	4.915364018	133.4384742	124.56	156.6419163	101.36	3	48.27966116	11565.00054	289.7087674	-0.59202
13-Apr	16	423	374.8373376	8.877605297	26.20442539	270.2594888	152.74	165.5195216	257.48	4	36.1088679	857.3372634	33131.58377	0.006034
13-May	17	367	381.5296651	8.877605297	-14.16275872	369.5521842	-2.55	174.3971269	192.60	1	0.695418037	16531.02084	15881.25043	0.096595
13-Jun	18	338	360.0534177	8.877605297	-16.95703068	373.4502397	-35.45	183.2747322	154.73	2	10.4882366	17548.58519	9413.042101	-0.04187
13-Jul	19	388	381.0498884	8.877605297	4.915364018	373.8463871	14.15	192.1523375	195.85	3	3.647838387	17653.69825	21615.12543	0.049309
13-Aug	20	397	373.546012	8.877605297	26.20442539	416.1319191	-19.13	201.0299428	195.97	4	4.819123193	30678.48668	24342.50043	-0.11017
13-Sep	21	412	419.874745	8.877605297	-14.16275872	368.2608586	43.74	209.9075481	202.09	1	10.61629646	16200.6291	29248.12543	0.39028
13-Oct	22	251	291.0732407	8.877605297	-16.95703068	411.7953196	-160.80	218.7851534	32.21	2	64.06188032	29178.1581	100.4171007	0.126957
13-Nov	23	273	272.6657768	8.877605297	4.915364018	304.86621	-31.87	227.6627587	45.34	3	11.6726044	4081.554308	1025.333767	0.273801
13-Dec	24	233	217.5414472	8.877605297	26.20442539	307.7478075	-74.75	236.540364	-3.54	4	32.08060407	4458.051398	63.66710069	0.194233
14-Jan	25	167	187.6688809	8.877605297	-14.16275872	212.2562938	-45.26	245.4179693	-78.42	1	27.09957711	825.0034273	5472.917101	-0.25994
14-Feb	26	223	233.7162566	8.877605297	-16.95703068	179.5894555	43.41	254.2955746	-31.30	2	19.46661189	3768.696638	323.250434	-0.57171
14-Mar	27	375	351.7563444	8.877605297	4.915364018	247.5092259	127.49	263.1731799	111.83	3	33.99753976	42.64167376	17961.58377	0.250236
14-Apr	28	293	280.2859398	8.877605297	26.20442539	386.838375	-93.84	272.0507852	20.95	4	32.02674916	21274.90867	2706.167101	0.204781
14-May	29	215	237.7885743	8.877605297	-14.16275872	275.0007864	-60.00	280.9283905	-65.93	1	27.90734251	1157.470609	674.9171007	-0.12693
14-Jun	30	257	270.0336513	8.877605297	-16.95703068	229.709149	27.29	289.8059958	-32.81	2	10.61900819	127.0132992	256.6671007	-0.00067
14-Jul	31	284	279.0597107	8.877605297	4.915364018	283.8266206	0.17	298.6836011	-14.68	3	0.061049084	1835.904309	1850.792101	0.077964
14-Aug	32	292	268.9787092	8.877605297	26.20442539	314.1417413	-22.14	307.5612064	-15.56	4	7.582788133	5352.762334	2603.125434	-0.55242
14-Sep	33	425	415.9730686	8.877605297	-14.16275872	263.6935558	161.31	316.4388117	108.56	1	37.95445746	515.9434726	33863.6671	0.169162
14-Oct	34	336	363.2925837	8.877605297	-16.95703068	407.8936432	-71.89	325.316417	10.68	2	21.39691761	27860.44247	9028.958767	0.437755
14-Nov	35	230	246.2299065	8.877605297	4.915364018	377.085553	-147.09	334.1940223	-104.19	3	63.95024045	18524.94841	120.5421007	-0.25951
14-Dec	36	341	306.2147167	8.877605297	26.20442539	281.3119372	59.69	343.0716276	-2.07	4	17.50383073	1626.73238	10004.1671	0.290116
15-Jan	37	202	230.3850418	8.877605297	-14.16275872	300.9295632	-98.93	351.9492329	-149.95	1	48.97503131	3594.05005	1519.375434	-0.20641
15-Feb	38	264	274.9629748	8.877605297	-16.95703068	222.3056165	41.69	360.8268382	-96.83	2	15.7933271	348.7014773	529.9587674	-0.43653
15-Mar	39	404	382.5169535	8.877605297	4.915364018	288.7559441	115.24	369.7044435	34.30	3	28.5257564	2282.620466	26575.7921	-0.35495
15-Apr	40	561	514.1799994	8.877605297	26.20442539	417.5989842	143.40	378.5820488	182.42	4	25.5616784	31194.55994	102413.3338	0.088939
15-May	41	459	480.3357271	8.877605297	-14.16275872	508.894846	-49.89	387.4596541	71.54	1	10.87033682	71778.81124	47533.08377	-0.01905
15-Jun	42	481	496.7000217	8.877605297	-16.95703068	472.2563017	8.74	396.3372594	84.66	2	1.817816696	53489.11318	57610.00043	0.082106
15-Jul	43	471	471.7622159	8.877605297	4.915364018	510.492991	-39.49	405.2148647	65.79	3	8.384923776	72637.7015	52909.58377	0.252323
15-Aug	44	388	378.8808267	8.877605297	26.20442539	506.8442466	-118.84	414.09247	-26.09	4	30.62996045	70684.24071	21615.12543	0.473185
15-Sep	45	190	230.5567866	8.877605297	-14.16275872	373.5956732	-183.60	422.9700753	-232.97	1	96.6293017	17587.13781	2598.875434	-0.77643
15-Oct	46	370	365.7489239	8.877605297	-16.95703068	222.4773612	147.52	431.8476806	-61.85	2	39.87098347	342.3168068	16646.37543	0.174438
15-Nov	47	315	319.3632889	8.877605297	4.915364018	379.5418933	-64.54	440.7252859	-125.73	3	20.48948992	19199.6292	5479.083767	-0.13509
15-Dec	48	397	364.677841	8.877605297	26.20442539	354.4453196	42.55	449.6028912	-52.60	4	10.71906308	12874.56786	24342.50043	0.159679
16-Jan	49	296				359.3926876	-63.39	458.4804965	-162.48	1	21.41644851	14655.36725	3325.444444	-0.33623
16-Feb	50	465				365.4760209	99.52	467.3581018	-2.36	2	21.40300625	16165.26301	51377.77778	0.062852
16-Mar	51	367				396.2260209	-29.23	476.235707	-109.24	3	7.963493439	24930.10079	16555.11111	0.40434
16-Apr	52	278				426.3926876	-148.39	485.1133123	-207.11	4	53.3786646	35366.32072	1573.444444	0.711882
16-May	53	197				394.9031088	-197.90	493.9909176	-296.99	1	100.4584309	24514.09458	1708.444444	0.842571
16-Jun	54	235				400.9864421	-165.99	502.8685229	-267.87	2	70.63252856	26456.03379	11.11111111	1.335049
16-Jul	55	118				431.7364421	-313.74	511.7461282	-393.75	3	265.8783408	37404.76248	14480.11111	2.558501
16-Aug	56	160				461.9031088	-301.90	520.6237335	-360.62	4	188.689443	49983.44449	6136.111111	1.046335
16-Sep	57	263				430.41353	-167.41	529.5013388	-266.50	1	63.65533459	36894.80194	608.4444444	0.830787
16-Oct	58	218				436.4968633	-218.50	538.3789441	-320.38	2	100.2279189	39268.78461	413.4444444	1.519481
16-Nov	59	136				467.2468633	-331.25	547.2565494	-411.26	3	243.5638701	52401.4042	10472.11111	2.723629
16-Dec	60	127				497.41353	-370.41	556.1341547	-429.13	4	291.6641968	67122.54829	12395.11111	

Appendix S. Additive Holt-Winters Sample (12 month)

Date	Time	SDRs	Estimate	Growth	Seasonal	Forecast	Error	Regression Estimates	Detrended	Averages / Seasons L=4	Percentage Error	Explained Variation	Total Variation	Theil's U
	-11				-75.40233753					-75.40233753				
	-10				-51.02994283					-51.02994283				
	-9				49.59245187					49.59245187				
	-8				100.9648466					100.9648466				
	-7				33.58724128					33.58724128				
	-6				32.70963598					32.70963598				
	-5				41.08203068					41.08203068				
	-4				15.45442539					15.45442539				
	-3				-0.67317991					-0.67317991				
	-2				-32.55078521					-32.55078521				
	-1				-75.92839051					-75.92839051				
	0		23.47783688	8.877605297	-37.8059958					-37.8059958				
12-Jan	1	30	85.93232499	8.877605297	-75.40233753	-43.04689535	73.05	32.35544218	-2.36	1	243.4896512	80670.80391	44512.20877	1.326
12-Feb	2	4	65.63295136	8.877605297	-51.02994283	43.77998746	-39.78	41.23304747	-37.23	2	994.4996864	38887.51628	56159.12543	30.77575
12-Mar	3	1	-15.78041916	8.877605297	49.59245187	124.1030085	-123.10	50.11065277	-49.11	3	12310.30085	13660.03634	57590.00043	92.06203
12-Apr	4	2	-74.4265151	8.877605297	100.9648466	94.06203272	-92.06	58.98825807	-56.99	4	4603.101636	21584.64425	57111.0421	-17.9808
12-May	5	4	-39.17251022	8.877605297	33.58724128	-31.96166852	35.96	67.86586337	-63.87	5	899.041713	74496.69951	56159.12543	0.353683
12-Jun	6	1	-31.33255176	8.877605297	32.70963598	2.41473106	-1.41	76.74346866	-75.74	6	141.473106	56912.98994	57590.00043	15.62708
12-Jul	7	3	-33.91676775	8.877605297	41.08203068	18.62708422	-15.63	85.62107396	-82.62	7	520.9028073	49440.44857	56634.08377	-3.86158
12-Aug	8	2	-16.54223596	8.877605297	15.45442539	-9.584737064	11.58	94.49867926	-92.50	8	579.2368532	62782.26985	57111.0421	-15.6689
12-Sep	9	23	15.32035996	8.877605297	-0.67317991	-8.337810575	31.34	103.3762846	-80.38	9	136.2513503	62158.95514	47514.9171	-0.40664
12-Oct	10	1	31.05787266	8.877605297	-32.55078521	-8.352819953	9.35	112.2538899	-111.25	10	935.2819953	62166.43955	57590.00043	-37.9929
12-Nov	11	2	67.8017112	8.877605297	-75.92839051	-35.99291255	37.99	121.1314952	-119.13	11	1899.645627	76713.53266	57111.0421	0.93666
12-Dec	12	37	75.30531309	8.877605297	-37.8059958	38.87332069	-1.87	130.0091004	-93.01	12	5.063028892	40846.77298	41607.50043	-1.60052
13-Jan	13	68	127.6179181	8.877605297	-75.40233753	8.780580852	59.22	138.8867057	-70.89	1	87.0873811	53916.18325	29921.7921	-0.34609
13-Feb	14	109	153.7570487	8.877605297	-51.02994283	85.46558058	23.53	147.764311	-38.76	2	21.59121048	24184.47546	17418.50043	-0.41993
13-Mar	15	258	196.2071826	8.877605297	49.59245187	212.2271059	45.77	156.6419163	101.36	3	17.74143183	826.6810003	289.7087674	-0.4533
13-Apr	16	423	290.863054	8.877605297	100.9648466	306.0496345	116.95	165.5195216	257.48	4	27.64784055	4234.165782	33131.58377	-0.0796
13-May	17	367	324.4377544	8.877605297	33.58724128	333.3279006	33.67	174.3971269	192.60	5	9.174958967	8528.288657	15881.25043	0.076362
13-Jun	18	338	312.7601821	8.877605297	32.70963598	366.0249957	-28.02	183.2747322	154.73	6	8.291418854	15636.45937	9413.042101	-0.07479
13-Jul	19	388	340.1797574	8.877605297	41.08203068	362.7198181	25.28	192.1523375	195.85	7	6.515510809	14820.7862	21615.12543	-0.08373
13-Aug	20	397	372.8861252	8.877605297	15.45442539	364.5117881	32.49	201.0299428	195.97	8	8.18342869	15260.30856	24342.50043	-0.07786
13-Sep	21	412	404.4345359	8.877605297	-0.67317991	381.0905506	30.91	209.9075481	202.09	9	7.502293541	19631.19991	29248.12543	0.314955
13-Oct	22	251	318.1375423	8.877605297	-32.55078521	380.761356	-129.76	218.7851534	32.21	10	51.69775139	19539.06045	100.4171007	-0.0873
13-Nov	23	273	343.0876068	8.877605297	-75.92839051	251.0867571	21.91	227.6627587	45.34	11	8.02682889	102.163385	1025.333767	0.297287
13-Dec	24	233	292.4382767	8.877605297	-37.8059958	314.1592163	-81.16	236.540364	-3.54	12	34.83228169	5355.319669	63.66710069	0.252848
14-Jan	25	167	258.1052287	8.877605297	-75.40233753	225.9135445	-58.91	245.4179693	-78.42	1	35.27757155	226.9729718	5472.917101	-0.0422
14-Feb	26	223	272.1515975	8.877605297	-51.02994283	215.9528912	7.05	254.2955746	-31.30	2	3.160138476	626.3144638	323.250434	-0.19901
14-Mar	27	375	313.5788874	8.877605297	49.59245187	330.6216546	44.38	263.1731799	111.83	3	11.83422543	8035.77565	17961.58377	0.34779
14-Apr	28	293	226.7978233	8.877605297	100.9648466	423.4213393	-130.42	272.0507852	20.95	4	44.51240249	33285.14635	2706.167101	0.185197
14-May	29	215	195.8759999	8.877605297	33.58724128	269.2626699	-54.26	280.9283905	-65.93	5	25.23845113	799.9565565	674.9171007	-0.09087
14-Jun	30	257	219.0830114	8.877605297	32.70963598	237.4632412	19.54	289.8059958	-32.81	6	7.601851686	12.36173211	256.6671007	-0.0582
14-Jul	31	284	238.9312175	8.877605297	41.08203068	269.0426474	14.96	298.6836011	-14.68	7	5.266673446	787.5589516	1850.792101	-0.10119
14-Aug	32	292	268.8860442	8.877605297	15.45442539	263.2632482	28.74	307.5612064	-15.56	8	9.841353361	496.5802892	2603.125434	-0.50654
14-Sep	33	425	386.2491852	8.877605297	-0.67317991	277.0904696	147.91	316.4388117	108.56	9	34.80224246	1304.026197	33863.6671	0.062532
14-Oct	34	336	375.6343875	8.877605297	-32.55078521	362.5760053	-26.58	325.316417	10.68	10	7.909525396	14785.79117	9028.958767	0.23388
14-Nov	35	230	326.874164	8.877605297	-75.92839051	308.5836023	-78.58	334.1940223	-104.19	11	34.16678362	4570.35972	120.5421007	-0.18719
14-Dec	36	341	367.3302674	8.877605297	-37.8059958	297.9457735	43.05	343.0716276	-2.07	12	12.62587288	3245.194291	10004.1671	0.289752
15-Jan	37	202	303.7380907	8.877605297	-75.40233753	300.8055352	-98.81	351.9492329	-149.95	1	48.91363128	3579.19437	1519.375434	-0.01195
15-Feb	38	264	314.3864464	8.877605297	-51.02994283	261.5857532	2.41	360.8268382	-96.83	2	0.914487417	424.6314093	529.9587674	-0.11797
15-Mar	39	404	346.1065209	8.877605297	49.59245187	372.8565036	31.14	369.7044435	34.30	3	7.708786241	17391.63199	26575.7921	-0.26003
15-Apr	40	561	432.0347188	8.877605297	100.9648466	455.9489728	105.05	378.5820488	182.42	4	18.7256733	46212.01755	102413.3338	0.027628
15-May	41	459	429.5440326	8.877605297	33.58724128	474.4995654	-15.50	387.4596541	71.54	5	3.37681163	54531.77662	47533.08377	-0.0215
15-Jun	42	481	445.6599412	8.877605297	32.70963598	471.1312739	9.87	396.3372594	84.66	6	2.051710208	52969.99246	57610.00043	0.051184
15-Jul	43	471	436.4801028	8.877605297	41.08203068	495.6195772	-24.62	405.2148647	65.79	7	5.227086449	64841.73866	52909.58377	0.154591
15-Aug	44	388	391.9530134	8.877605297	15.45442539	460.8121335	-72.81	414.09247	-26.09	8	18.76601378	48326.53329	21615.12543	0.541643
15-Sep	45	190	246.6888114	8.877605297	-0.67317991	400.1574388	-210.16	422.9700753	-232.97	9	110.6091783	25337.72232	2598.875434	-0.7736
15-Oct	46	370	363.3733844	8.877605297	-32.55078521	223.0156315	146.98	431.8476806	-61.85	10	39.72550501	322.6885969	16646.37543	-0.05048
15-Nov	47	315	385.9500923	8.877605297	-75.92839051	296.3225992	18.68	440.7252859	-125.73	11	5.929333599	3062.895521	5479.083767	-0.12692
15-Dec	48	397	424.1501293	8.877605297	-37.8059958	357.0217018	39.98	449.6028912	-52.60	12	10.07010031	13465.86996	24342.50043	0.155228
16-Jan	49	296				357.625397	-61.63	458.4804965	-162.48	1	20.81939089	14230.59646	3325.444444	-0.25042
16-Feb	50	465				390.875397	74.12	467.3581018	-2.36	2	15.94077483	23269.0812	51377.77778	0.286829
16-Mar	51	367				500.375397	-133.38	476.235707	-109.24	3	36.34207004	68666.04315	16555.11111	0.770096
16-Apr	52	278				560.625397	-282.63	485.1133123	-207.11	4	101.6638119	103872.1743	1573.444444	1.097573
16-May	53	197				502.125397	-305.13	493.9909176	-296.99	5	154.8859883	69586.25287	1708.444444	1.396576
16-Jun	54	235				510.125397	-275.13	502.8685229	-267.87	6	117.074637	73870.92589	11.11111111	1.742023
16-Jul	55	118				527.375397	-409.38	511.7461282	-393.75	7	346.9283026	83545.31459	14480.11111	2.971402
16-Aug	56	160				510.625397	-350.63	520.6237335	-360.62	8	219.1408731	74142.96795	6136.111111	1.502346
16-Sep	57	263				503.375397	-240.38	529.5013388	-266.50	9	91.39748937	70247.29553	608.4444444	0.997625
16-Oct	58	218				480.375397	-262.38	538.3789441	-320.38	10	120.3556867	58584.3606	413.4444444	1.421447
16-Nov	59	136				445.875397	-309.88	547.2565494	-411.26	11	227.8495566	43073.70821	10472.11111	2.69026
16-Dec	60	127				492.875397	-365.88	556.1341547	-429.13	12	288.0908638	64791.66219	12395.11111	

Appendix T. Multiplicative Holt-Winters Sample (4 months)

Date	Time	SDRs	Estimate	Growth	Seasonal	Forecast	Error	(Error/ Forecast)^2	Regression Estimates	Detrended	Averages / Seasons	Percentage Error	Explained Variation	Total Variation	Theil's U
	-3				0.042841892						0.04284189				
	-2				0.044065692						0.04406569				
	-1				0.050235804						0.0502358				
	0		4986.873	-0.11678	0.056290425						0.05629042				
12-Jan	1	30	971.6369	-0.11678	0.042841892	213.6420765	-183.64	0.73887472	4986.75631	0.00601593	1	612.140255	747.316497	44512.2088	1.29369
12-Feb	2	4	146.5355	-0.11678	0.044065692	42.8107083	-38.8107	0.82186088	4986.63953	0.00080214	2	970.267708	39270.7379	56159.1254	1.588865
12-Mar	3	1	27.9159	-0.11678	0.050235804	7.355460996	-6.35546	0.74657651	4986.52275	0.00020054	3	635.5461	54580.0359	57590.0004	-0.43518
12-Apr	4	2	35.04056	-0.11678	0.056290425	1.564824045	0.435176	0.07733904	4986.40597	0.00040109	4	21.7587977	57319.2275	57111.0421	-1.2519
12-May	5	4	89.66642	-0.11678	0.042841892	1.496200825	2.503799	2.80039442	4986.28919	0.0008022	1	62.5949794	57352.0909	56159.1254	0.736517
12-Jun	6	1	26.9262	-0.11678	0.044065692	3.946066944	-2.94607	0.55738634	4986.17241	0.00020055	2	294.606694	56184.6904	57590.0004	-1.65321
12-Jul	7	3	57.63483	-0.11678	0.050235804	1.346792729	1.653207	1.50679124	4986.05562	0.00060168	3	55.106909	57423.6746	56634.0838	0.412572
12-Aug	8	2	36.92213	-0.11678	0.056290425	3.237715315	-1.23772	0.14613835	4985.93884	0.00040113	4	61.8857657	56520.9977	57111.0421	-10.7116
12-Sep	9	23	505.1983	-0.11678	0.042841892	1.576810753	21.42319	184.590396	4985.82206	0.00461308	1	93.1443011	57313.488	47514.9171	0.924207
12-Oct	10	1	53.2344	-0.11678	0.044065692	22.2567687	-21.2568	0.91215841	4985.70528	0.00020057	2	2125.67687	47839.4874	57590.0004	0.668406
12-Nov	11	2	40.65463	-0.11678	0.050235804	2.668406172	-0.66841	0.0627447	4985.5885	0.00040116	3	33.4203086	56792.0186	57111.0421	-17.3591
12-Dec	12	37	618.2566	-0.11678	0.056290425	2.281892889	34.71811	231.484314	4985.47172	0.00742156	4	93.8327219	56976.3885	41607.5004	-1.1221
13-Jan	13	68	1525.876	-0.11678	0.042841892	26.48227742	41.51772	2.45785571	4985.35494	0.01363995	1	61.0554744	46008.9155	29921.7921	-0.61421
13-Feb	14	109	2413.571	-0.11678	0.044065692	67.23364741	41.76635	0.38590442	4985.23815	0.02186455	2	38.3177547	30187.5055	17418.5004	-1.25466
13-Mar	15	258	4963.423	-0.11678	0.050235804	121.2418219	136.7582	1.27233568	4985.12137	0.05175401	3	53.0070458	14337.0317	289.708767	-0.55664
13-Apr	16	423	7353.072	-0.11678	0.056290425	279.3866228	143.6134	0.26422784	4985.00459	0.08485449	4	33.951153	1475.13269	33131.5838	-0.1229
13-May	17	367	8489.557	-0.11678	0.042841892	315.0145079	51.98549	0.02723348	4984.88781	0.07362252	1	14.1649842	5481.23176	15881.2504	0.098346
13-Jun	18	338	7722.224	-0.11678	0.044065692	374.0930645	-36.0931	0.00930868	4984.77103	0.06780652	2	10.6784214	17719.3098	9413.0421	-0.00022
13-Jul	19	388	7723.482	-0.11678	0.050235804	387.9262435	0.073756	3.6149E-08	4984.65425	0.0778389	3	0.0190094	21593.4434	21615.1254	0.097298
13-Aug	20	397	7095.17	-0.11678	0.056290425	434.7515092	-37.7515	0.00754026	4984.53746	0.07964631	4	9.50919628	37547.7207	24342.5004	-0.27213
13-Sep	21	412	9457.101	-0.11678	0.042841892	303.9655016	108.0345	0.12632122	4984.42068	0.08265755	1	26.2219656	3967.27839	29248.1254	0.402254
13-Oct	22	251	5934.154	-0.11678	0.044065692	416.7285649	-165.729	0.15815692	4984.3039	0.05035809	2	66.0273167	30887.851	100.417101	0.100005
13-Nov	23	273	5466.006	-0.11678	0.050235804	298.1011524	-25.1012	0.00709022	4984.18712	0.05477322	3	9.19456133	3262.92126	1025.33377	0.273543
13-Dec	24	233	4223.24	-0.11678	0.056290425	307.6772249	-74.6772	0.05890954	4984.07034	0.04674894	4	32.0503111	4448.63097	63.6671007	0.059771
14-Jan	25	167	3918.635	-0.11678	0.042841892	180.9265889	-13.9266	0.00592495	4983.95356	0.03350754	1	8.33927476	3606.3121	5472.9171	-0.30136
14-Feb	26	223	4988.317	-0.11678	0.044065692	172.672201	50.3278	0.08495149	4983.83677	0.04474464	2	22.5685197	4665.84156	323.250434	-0.55791
14-Mar	27	375	7307.997	-0.11678	0.050235804	250.5862483	124.4138	0.24650305	4983.71999	0.075245	3	33.1770005	92.2960171	17961.5838	0.315636
14-Apr	28	293	5338.277	-0.11678	0.056290425	411.3636791	-118.364	0.08279136	4983.60321	0.0587928	4	40.3971601	29030.8821	2706.1671	0.046747
14-May	29	215	5038.694	-0.11678	0.042841892	228.6968647	-13.6969	0.00358692	4983.48643	0.04314249	1	6.37063473	150.854942	674.917101	-0.16266
14-Jun	30	257	5781.956	-0.11678	0.044065692	222.0283853	34.97161	0.02480929	4983.36965	0.05157153	2	13.6076322	359.132115	256.667101	0.025118
14-Jul	31	284	5661.474	-0.11678	0.050235804	290.4553191	-6.45532	0.00049394	4983.25287	0.05699089	3	2.27299967	2447.88966	1850.7921	0.093944
14-Aug	32	292	5217.391	-0.11678	0.056290425	318.6802027	-26.6802	0.00700919	4983.13609	0.05859764	4	9.13705573	6037.451	2603.12543	-0.69001
14-Sep	33	425	9622.445	-0.11678	0.042841892	223.5179186	201.4821	0.8125464	4983.0193	0.08528966	1	47.4075486	304.895184	33863.6671	0.207093
14-Oct	34	336	7751.436	-0.11678	0.044065692	424.0145502	-88.0146	0.04308712	4982.90252	0.06743058	2	26.1948066	33501.9516	9028.95877	0.474386
14-Nov	35	230	4779.292	-0.11678	0.050235804	389.3937445	-159.394	0.16755778	4982.78574	0.04615892	3	69.3016281	22026.8869	120.542101	-0.31295
14-Dec	36	341	5976.912	-0.11678	0.056290425	269.0217749	71.97823	0.07158589	4982.66896	0.06843722	4	21.1079839	786.387875	10004.1671	0.158526
15-Jan	37	202	4794.897	-0.11678	0.042841892	256.0572114	-54.0572	0.04456904	4982.55218	0.04054147	1	26.7609957	227.347433	1519.37543	-0.26096
15-Feb	38	264	5915.317	-0.11678	0.044065692	211.2853253	52.71467	0.06224786	4982.4354	0.05298614	2	19.9676798	881.724213	529.958767	-0.40472
15-Mar	39	404	7907.416	-0.11678	0.050235804	297.1548217	106.8452	0.12928385	4982.31861	0.08108675	3	26.4468263	3155.70422	26575.7921	-0.28687
15-Apr	40	561	9835.82	-0.11678	0.056290425	445.1052378	115.8948	0.06779571	4982.20183	0.11260082	4	20.6586029	41667.4529	102413.334	-0.06706
15-May	41	459	10658.22	-0.11678	0.042841892	421.3801184	37.61988	0.00797052	4982.08505	0.0921301	1	8.19605264	32544.5034	47533.0838	-0.02471
15-Jun	42	481	10899.22	-0.11678	0.044065692	469.6565883	11.34341	0.00058335	4981.96827	0.09654819	2	2.35829765	52293.3632	57610.0004	0.159096
15-Jul	43	471	9472.228	-0.11678	0.050235804	547.5253848	-76.5254	0.01953451	4981.85149	0.09454316	3	16.2474278	93970.5839	52909.5838	0.308257
15-Aug	44	388	7056.124	-0.11678	0.056290425	533.1891537	-145.189	0.07414907	4981.73471	0.07788452	4	37.419885	85386.6766	21615.1254	0.289414
15-Sep	45	190	4600.859	-0.11678	0.042841892	302.2927111	-112.293	0.13799005	4981.61793	0.03814022	1	59.1014269	3759.35073	2598.87543	-0.88034
15-Oct	46	370	8156.234	-0.11678	0.044065692	202.7348723	167.2651	0.6806971	4981.50114	0.0742748	2	45.2067913	1462.62605	16646.3754	0.256025
15-Nov	47	315	6389.815	-0.11678	0.050235804	409.7291023	-94.7291	0.05345314	4981.38436	0.06323543	3	30.0727309	28476.5408	5479.08377	-0.11848
15-Dec	48	397	7010.733	-0.11678	0.056290425	359.6788297	37.32117	0.01076665	4981.26758	0.07969859	4	9.40079856	14089.61	24342.5004	16.91367
16-Jan	49	296				7010.727658	-6714.73	0.91734059	4981.1508	0.05942402	1	2268.48907	45865324.9	3325.44444	22.11393
16-Feb	50	465				7010.722369	-6545.72	0.87174532	4981.03402	0.09335411	2	1407.68223	45865253.3	51377.7778	14.28756
16-Mar	51	367				7010.715061	-6643.72	0.89804348	4980.91724	0.07368121	3	1810.27658	45865154.3	16555.1111	18.34525
16-Apr	52	278				7010.706366	-6732.71	0.92226514	4980.80045	0.05581432	4	2421.83682	45865036.5	1573.44444	24.50974
16-May	53	197				7010.707645	-6813.71	0.94458986	4980.68367	0.0395528	1	3458.73485	45865053.8	1708.44444	34.39443
16-Jun	54	235				7010.701785	-6775.7	0.93408324	4980.56689	0.04718338	2	2883.27736	45864974.4	11.1111111	29.3306
16-Jul	55	118				7010.691595	-6892.69	0.96662043	4980.45011	0.02369264	3	5841.26406	45864836.4	14480.1111	58.05661
16-Aug	56	160				7010.680072	-6850.68	0.95487621	4980.33333	0.03212636	4	4281.67504	45864680.3	6136.11111	42.17305
16-Sep	57	263				7010.687633	-6747.69	0.92637901	4980.21655	0.05280895	1	2565.6607	45864782.8	608.444444	25.82769
16-Oct	58	218				7010.681201	-6792.68	0.93877611	4980.09977	0.04377422	2	3115.90881	45864695.6	413.444444	31.53517
16-Nov	59	136				7010.668128	-6874.67	0.96157831	4979.98298	0.02730933	3	5054.90304	45864518.6	10472.1111	50.6151
16-Dec	60	127				7010.653777	-6883.65	0.96409759	4979.8662	0.02550269	4	5420.19982	45864324.2	12395.1111	

Appendix U. Multiplicative Holt-Winters Sample (12 month)

Date	Time	SDRs	Estimate	Growth	Seasonal	Forecast	Error	(Error/ Forecast)^2	Regression Estimates	Detrended	Averages / Seasons	Percentage Error	Explained Variation	Total Variation	Theil's U
	-11				0.667806733						0.667806733				
	-10				0.610813988						0.610813988				
	-9				1.046176646						1.046176646				
	-8				1.287086215						1.287086215				
	-7				1.02832283						1.02832283				
	-6				0.989417326						0.989417326				
	-5				1.041863644						1.041863644				
	-4				0.970596953						0.970596953				
	-3				0.994383262						0.994383262				
	-2				0.761444188						0.761444188				
	-1				0.654651749						0.654651749				
	0		23.47784	8.877605	0.78664779						0.78664779				
12-Jan	1	30	31.87357	8.877604	0.982184732	21.60718213	8.39	0.15087571	32.3554422	0.92720105	1	27.9760596	48124.0676	44512.2088	0.69638
12-Feb	2	4	32.9261	8.877584	0.614606265	24.89138672	-20.8914	0.70442758	41.2330475	0.09700957	2	522.284668	46693.9286	56159.1254	10.68351
12-Mar	3	1	32.92532	8.87756	0.511411584	43.73403587	-42.734	0.95479186	50.1106528	0.01995584	3	4273.40359	38905.6416	57590.0004	51.80392
12-Apr	4	2	33.14843	8.877538	0.619996272	53.80391719	-51.8039	0.92703773	58.9882581	0.03390505	4	2590.19586	35034.574	57111.0421	19.60813
12-May	5	4	33.65962	8.877516	0.78409075	43.21625791	-39.2163	0.82345142	67.8658634	0.05893979	5	980.406448	39110.1681	56159.1254	10.27175
12-Jun	6	1	33.51904	8.877492	0.480431044	42.086984	-41.087	0.95304392	76.7434687	0.01303042	6	4108.6984	39558.1003	57590.0004	41.17141
12-Jul	7	3	34.34388	8.877471	0.414111668	44.17140723	-41.1714	0.86877827	85.621074	0.0350381	7	1372.38024	38733.2942	56634.0838	13.31684
12-Aug	8	2	34.40485	8.877448	0.491077154	41.95050726	-39.9505	0.90692247	94.4986793	0.02116432	8	1997.52536	39612.4073	57111.0421	10.0196
12-Sep	9	23	40.20743	8.87744	0.735434527	43.03919356	-20.0392	0.2167865	103.376285	0.22248817	9	87.1269285	39180.233	47514.9171	1.581539
12-Oct	10	1	38.72358	8.877413	0.376122111	37.37538971	-36.3754	0.94720471	112.25389	0.00890838	10	3637.53897	41454.498	57590.0004	29.16207
12-Nov	11	2	38.17259	8.877388	0.331115969	31.16207152	-29.1621	0.87575798	121.131495	0.01651098	11	1458.10358	44023.2134	57111.0421	0.005882
12-Dec	12	37	53.28716	8.877404	0.537718085	37.01176399	-0.01176	1.0103E-07	130.0091	0.28459546	12	0.03179456	41602.7014	41607.5004	-0.18765
13-Jan	13	68	68.84332	8.877422	0.793328	61.05708533	6.942915	0.01293039	138.886706	0.4896077	1	10.2101686	32371.9554	29921.7921	-0.90048
13-Feb	14	109	124.4708	8.877544	0.490751313	47.76765352	61.23235	1.64321348	147.764311	0.73766121	2	56.1764647	37330.6888	17418.5004	-1.74132
13-Mar	15	258	275.7143	8.877917	0.469848712	68.19586842	189.8041	7.74631574	156.641916	1.64706872	3	73.5674929	29854.0682	289.708767	-0.95564
13-Apr	16	423	395.266	8.878207	0.65988737	176.4460896	246.5539	1.95253899	165.519522	2.55558979	4	58.2869765	4164.51804	33131.5838	-0.11847
13-May	17	367	417.0318	8.87824	0.813221364	316.8857377	50.11426	0.02501021	174.397127	2.10439247	5	13.6551123	5761.80753	15881.2504	-0.36343
13-Jun	18	338	483.8475	8.878392	0.538434377	204.6204202	133.3796	0.42489414	183.274732	1.84422586	6	39.4614141	1321.95844	9413.0421	-0.54425
13-Jul	19	388	566.1473	8.878584	0.519291517	204.0435437	183.9565	0.81280123	192.152338	2.01923123	7	47.4114578	1364.24024	21615.1254	-0.29541
13-Aug	20	397	580.8877	8.8786	0.665290737	282.3820643	114.6179	0.1647521	201.029943	1.97483019	8	28.8710165	1714.19993	24342.5004	0.054747
13-Sep	21	412	571.4394	8.878552	0.79205818	433.7345112	-21.7345	0.00251103	209.907548	1.96276887	9	5.2753668	37154.6229	29248.1254	-0.07944
13-Oct	22	251	555.1547	8.878486	0.518631098	218.2703963	32.7296	0.02248494	218.785153	1.14724421	10	13.0396827	515.68825	100.417101	-0.34358
13-Nov	23	273	555.5867	8.878464	0.512885527	186.7603872	86.23961	0.21322792	227.662759	1.19914211	11	31.5896018	2939.67605	1025.33377	0.258326
13-Dec	24	233	517.2382	8.87834	0.616000291	303.5231259	-70.5231	0.0539858	236.540364	0.98503273	12	30.267436	3911.74684	63.6671007	1.074605
14-Jan	25	167	456.6186	8.878158	0.694238223	417.3829881	-250.383	0.35986545	245.417969	0.68047177	1	149.929933	31118.3082	5472.9171	0.032594
14-Feb	26	223	457.6671	8.878138	0.511431601	228.4431402	-5.44314	0.00056773	254.295575	0.87693229	2	2.44087005	157.151959	323.250434	-0.69863
14-Mar	27	375	524.8756	8.87829	0.559135373	219.2056862	155.7943	0.50512583	263.17318	1.42491724	3	41.5451503	474.084451	17961.5838	0.157913
14-Apr	28	293	520.9454	8.878257	0.60371072	352.2174245	-59.2174	0.02826685	272.050785	1.07700479	4	20.2107251	12373.95	2706.1671	0.736737
14-May	29	215	481.2985	8.87813	0.637442818	430.8639288	-215.864	0.25100356	280.928391	0.76531959	5	100.401827	36056.2229	674.917101	0.032223
14-Jun	30	257	492.8956	8.878137	0.513720815	263.9279383	-6.92794	0.00068903	289.805996	0.88680015	6	2.69569585	526.646121	256.667101	-0.09118
14-Jul	31	284	503.1301	8.87814	0.560358544	260.5668271	23.43317	0.00808768	298.683601	0.95083894	7	8.25111722	383.676441	1850.7921	0.171248
14-Aug	32	292	505.7627	8.878124	0.597661352	340.6343639	-48.6344	0.02038495	307.561206	0.94940452	8	16.6556041	9931.15834	2603.12543	-0.0595
14-Sep	33	425	548.1661	8.878212	0.66907681	407.6254361	17.37456	0.00181679	316.438812	1.34307166	9	4.08813268	27770.9791	33863.6671	-0.11082
14-Oct	34	336	578.4283	8.878268	0.529131403	288.9005037	47.0995	0.02657883	325.316417	1.03284059	10	14.0177072	2296.45454	9028.95877	0.211967
14-Nov	35	230	548.3212	8.878166	0.528030071	301.2210642	-71.2211	0.05590443	334.194022	0.68822296	11	30.9656801	3629.08621	120.542101	0.009717
14-Dec	36	341	560.1439	8.878173	0.6002107	343.2349655	-2.23497	4.2399E-05	343.071628	0.99396153	12	0.6554151	10456.2484	10004.1671	0.566091
15-Jan	37	202	510.1404	8.878019	0.606412711	395.0368906	-193.037	0.23878405	351.949233	0.57394641	1	95.5628171	23733.7823	1519.37543	0.007141
15-Feb	38	264	514.5904	8.878008	0.52543683	265.4424033	-1.4424	2.9528E-05	360.826838	0.73165289	2	0.54636489	598.449947	529.958767	-0.42163
15-Mar	39	404	576.7347	8.878147	0.567602	292.6896784	111.3103	0.14462923	369.704443	1.09276479	3	27.5520598	2673.97703	26575.7921	-0.51351
15-Apr	40	561	662.5584	8.878349	0.656771421	353.5407447	207.4593	0.34433937	378.582049	1.48184522	4	36.9802594	12670.1088	102413.334	-0.05525
15-May	41	459	690.2783	8.878398	0.619843836	428.002511	30.99749	0.00524518	387.459654	1.18463947	5	6.75326558	34977.7313	47533.0838	-0.26542
15-Jun	42	481	746.831	8.878523	0.552653519	359.1713236	121.8287	0.11505242	396.337259	1.21361287	6	25.3282071	13969.386	57610.0004	-0.09882
15-Jul	43	471	772.0433	8.878565	0.577346079	423.4683139	47.53169	0.01259867	405.214865	1.1623463	7	10.0916531	33302.2888	52909.5838	0.167148
15-Aug	44	388	739.0051	8.878456	0.626543586	466.7268461	-78.7268	0.02845248	414.09247	0.93698878	8	20.2904243	50962.0148	21615.1254	0.799978
15-Sep	45	190	650.5926	8.878201	0.544630037	500.3915401	-310.392	0.38476879	422.970075	0.44920436	9	163.363968	67294.7795	2598.87543	-0.11081
15-Oct	46	370	661.681	8.878207	0.554151433	348.9467125	21.05329	0.00364017	431.847681	0.85678358	10	5.6900777	11656.991	16646.3754	0.105609
15-Nov	47	315	643.0136	8.878135	0.557277295	354.0754259	-39.0754	0.01217912	440.725286	0.71473094	11	12.4048971	12790.7638	5479.08377	-0.01818
15-Dec	48	397	647.8673	8.878124	0.623385515	391.2723692	5.727631	0.00021428	449.602891	0.88300144	12	1.44272816	22588.0467	24342.5004	0.899877
16-Jan	49	296	631.7793	8.878059	0.527166247	653.2510672	-357.251	0.29907962	458.480496	0.64561089	1	120.692928	172156.726	3325.44444	0.649314
16-Feb	50	465	684.4061	8.878173	0.582894408	657.1970467	-192.197	0.0855268	467.358102	0.9949544	2	41.3326982	175446.81	51377.7778	0.636527
16-Mar	51	367	685.6295	8.878153	0.552228786	662.984983	-295.985	0.19931132	476.235707	0.7706268	3	80.6498591	180329.024	16555.1111	1.071365
16-Apr	52	278	639.7168	8.87801	0.580061444	671.1908528	-393.191	0.3431743	485.113312	0.57306199	4	141.435559	187365.632	1573.44444	1.7208
16-May	53	197	587.9969	8.877851	0.483082177	675.3825126	-478.383	0.50170793	493.990918	0.39879276	5	242.833763	191011.985	1708.44444	2.24521
16-Jun	54	235	554.173	8.87774	0.546449004	677.3064193	-442.306	0.42645784	502.868523	0.46731897	6	188.215498	192697.37	11.1111111	2.407436
16-Jul	55	118	486.0364	8.877538	0.481226242	683.7475112	-565.748	0.68462663	511.746128	0.23058308	7	479.447043	198393.79	14480.1111	4.511589
16-Aug	56	160	446.6203	8.877412	0.529166234	692.3675139	-532.368	0.59122083	520.623734	0.30732368	8	332.729696	206147.037	6136.11111	2.677406
16-Sep	57	263	475.0997	8.877463	0.499255061	691.3848978	-428.385	0.38390921	529.501339	0.49669374	9	162.883992	205255.72	608.444444	1.821542
16-Oct	58	218	465.2317	8.877414	0.528582935	697.0655123	-479.066	0.47232684	538.378944	0.40491925	10	219.754822	210435.212	413.444444	2.597663
16-Nov	59	136	431.8959	8.877303	0.44306079	702.2906072	-566.291	0.65019705	547.256549	0.24851233	11	416.390152	215256.352	10472.1111	4.318244
16-Dec	60	127	396.5154	8.877187	0.48123993	714.2811881	-587.281	0.67601099	556.134155	0.22836217	12	462.426132	226526.36	12395.1111	

Appendix V. Comparison Chart Sample

	Parameters - Forecast					Parameters - Validation				
Model	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**	**SSE**	**R^2**	**MAPE**	**RAE**	**Theil's U**
Simple Linear Regression	547,765.9791	0.5700	918.2251	8.7270	8.3963	1,053,230.1813	N/A	156.0059	4.2638	4.6866
Trend	443,777.8853	0.6516	541.9315	5.1506	6.2384	3,778,907.6126	N/A	244.0812	6.6710	7.9074
Dummy	332,247.9686	0.7392	749.2357	7.1209	7.2947	253,303.4940	N/A	70.4338	1.9250	2.6174
Trigonometric L=1	346,981.3837	0.7276	695.2192	6.6075	6.9984	256,778.1254	N/A	70.6521	1.9310	2.6410
Trigonometric L=2	255,602.3133	0.7993	516.9129	4.9128	4.8568	87,442.1374	0.1918	27.1052	0.7408	1.7872
Trigonometric L=3	241,864.8892	0.8101	252.2433	2.3974	2.6642	1,681,249.8609	N/A	194.6971	5.3213	5.8435
Trigonometric L=4	392,137.2423	0.6921	491.4584	4.6709	5.3668	9,001,500.8862	N/A	446.2608	12.1968	14.1627
Autocorrelation L=1	248,146.1132	0.7195	426.6123	4.0546	3.4470	153,966.8239	N/A	52.0046	1.4213	2.0378
Autocorrelation L=2	241,909.0066	0.7790	311.9037	2.9644	3.7045	66,550.5110	0.4432	25.0538	0.6848	1.7729
Autocorrelation L=3	272,459.2213	0.7388	348.8045	3.3151	3.4846	356,041.6010	N/A	90.2896	2.4677	2.8390
Autocorrelation L=4	275,752.9628	0.7426	333.0615	3.1655	3.2291	674,866.9078	4.4616	124.9342	3.4146	3.8561
Decomp Multiplicative (12)	72,648.8793	0.9293	58.2910	0.5540	0.5259	148,429.0356	N/A	35.5466	0.9715	0.5259
Decomp Multiplicative (4)	202,104.8571	N/A	50.9013	0.4838	0.4919	25,728.2731	0.7711	19.8526	0.5426	1.6770
Decomp Additive (12)	67,957.8051	0.9076	172.9174	1.6434	2.4441	147,516.2776	N/A	37.2796	1.0189	2.6689
Simple Exponential Smoothing	360,980.3971	0.9631	124.2234	1.1806	0.9996	382,435.2525	N/A	94.5201	2.5833	2.8340
Holt's Trend	358,780.7256	N/A	337.7812	3.2103	2.0564	1,205,419.7456	N/A	165.9634	4.5360	5.1332
Additive Holt-Winters (4)	306,610.6828	0.9907	318.1860	3.0241	3.0947	615,790.2238	N/A	119.0776	3.2545	3.7524
Additive Holt-Winters (12)	236,270.6315	0.9586	501.2674	4.7641	5.1958	922,788.8830	N/A	145.0408	3.9641	4.3189
Multiplicative Holt-Winters (4)	354,268.1057	N/A	125.3312	1.1912	1.2884	550,497,652.5899	N/A	3,377.4924	92.3108	92.7845
Multiplicative Holt-Winters (12)	558,912.2270	N/A	463.7781	4.4078	3.7588	2,513,346.0312	N/A	240.7327	6.5795	6.8933
ARIMA (0, 0, 3 - 4)	324,848.7770	0.7343	328.5562	3.1227		324,848.7770	0.7343	328.5562	3.1227	
ARIMA (0, 0, 3 - 12)	312,921.3950	0.6414	856.5431	8.1407		312,921.3950	0.6414	856.5431	8.1407	
ARIMA (3, 0, 3 - 4)	274,415.3320	0.7386	579.0583	5.5035		274,415.3320	0.7386	579.0583	5.5035	
ARIMA (3, 0, 3 - 12)	55,835.5582	0.7769	216.9510	2.0619		55,835.5582	0.7769	216.9510	2.0619	

Bibliography

Arminger, G. (2003). The CPFR Concept: 2.2. Sales and Order Forecasts in the CPFR Process for Retail. In *Collaborative Planning, Forecasting & Replenishment* (pp. 41–57). AMACOM. ISBN 978-0814471821

Armstrong, J. S. (2001a). Combining forecasts. In *Principles of Forecasting: A Handbook for Researchers and Practitioners* (pp. 417-439). Kluwer Academic Publishers. ISBN 978-0-306-47630-3

Armstrong, J. S. (2001b). *Principles of Forecasting: A Handbook for Researchers and Practitioners*. Kluwer Academic Publishers. ISBN 978-0-306-47630-3

Bowerman, O'Connell, & Koehler. (2004). *Forecasting, Times Series, and Regression: An Applied Approach* (4th ed.). South-Western College Publishing. ISBN 978-0534409777

Craig, N., Dehoratius, N., Jiang, Y., & Klabjan, D. (2014). Execution Quality : An Analysis of Fulfillment Errors in a Retail Distribution Center. In *Journal of Operations Management* Vol. 38 (pp. 1–40). Elsevier B.V.

Hyndman, R. J., & Athanasopoulos, G. (2013). *Forecasting: Principles and Practice*. OTexts. ISBN 978-0987507105

Morely, H. R. (2016). Paid In Full. In *Journal of Commerce*. UBM Global Trade

Marion, R. (2013). Avionic Support for the Foreign Military Sales Customer. The Boeing Company. DOI: 10.1109/AUTEST.2013.6645042

Norris, R. S. & Kristensen, H. M. (2008). U.S. nuclear forces, Bulletin of the Atomic Scientists Vol. 64, Issue 1 (pp. 50-58). http://doi.org/10.1080/00963402.2008.11461134

Plante, D. E. (2010). Revitalizing the Nuclear Weapons Enterprise (pp. 1-30). U.S. Army War College. handle.dtic.mil/100.2/ADA521983

Spencer, M., Nelson, H., Larry, C. (2012). The Unauthorized Movement of Nuclear Weapons and Mistaken Shipment of Classified Missile Components : An Assessment. USAF Counterproliferation Center: Air University. www.dtic.mil/get-tr-doc/pdf?AD=ADA557097

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
23-03-2017	Master's Thesis	September 2015 – March 2017

4. TITLE AND SUBTITLE

An Analysis of Forecasting Methods on Supply Discrepancy Reporting

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Freeborn, Cody, S, Capt

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way
Wright-Patterson AFB Oh 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT-ENS-MS-17-M-130

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Installation and Mission Support Center
Ms. Lynda Lowin, Chief of Logistics Support
JBSA-Lackland, TX
Lynda.lowin@us.af.mil

10. SPONSOR/MONITOR'S ACRONYM(S)
AFIMSC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution Statement A. Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

This work is declared a work of the U.S. Government and is not subject to copyright protection in the United States

14. ABSTRACT

The Department of Defense (DoD) tracks and records all cargo shipments as they move from one location to the next. Inevitably, there are mistakes that are made when dealing with these shipments. Currently the Air Force does not use any forecasting techniques to predict these shipping discrepancies, thus it has no way to prepare for them other than employing remedial measures after errors occur.

The purpose of this research is to study the current Air Force shipping processes, specifically shipping discrepancies, and determine if any trends emerge. By examining historical shipment discrepancy data, a trend analysis was accomplished and from this data a relatively accurate forecast was developed.

In the final analysis, it was concluded that three models most accurately forecasted the behavior of the discrepancy codes studied. These three models can be utilized in determining the root causes of these discrepancy trends.

15. SUBJECT TERMS

Forecasting, Supply Discrepancy Report, Supply Chain

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Capt Michael Kretser
U	U	U	UU	96	19b. TELEPHONE NUMBER *(include area code)* 937-255-3636 x4728 michael.kretser@afit.edu

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18