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GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

FORECASTING AND INVENTORY CONTROL IN A COMPANY IN IZMIR, TURKEY

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This study titled “FORECASTING AND INVENTORY CONTROL IN A COMPANY IN IZMIR, TURKEY” and presented as Master’s Thesis by AISHA IBRAHIM HASSAN has been evaluated in compliance with the relevant provisions of Y.U Graduate Education and Training Regulation and Y.U Institute of Science Education and Training Direction and jury members written below have decided for the defense of this thesis and it has been declared by consensus / majority of votes that the candidate has succeeded in thesis defense examination dated 25/06/2014

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TEXT OF OATH

I declare and honestly confirm that my study titled “Forecasting and inventory control in a Company in Izmir, Turkey”, and presented as Master’s Thesis has been written without applying to any assistance inconsistent with scientific ethics and traditions and all sources I have benefited from are listed in bibliography and I have benefited from these sources by means of making references.

25/06/2014

Aisha Ibrahim HASSAN

ÖZET

IZMIR'DE ŞIRKETTE TAHMINLEME VE ENVANTER KONTROLÜ

HASSAN, Aisha Ibrahim

Yüksek Lisans Tezi, Endüstriyel Yönetim ve Bilişim Sistemleri Bölümü

Tez Danışmanı: Assoc. Prof. Dr. Mehmet Fatih TAŞGETİREN

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Bu çalışma bir hammadde üreticisi olan Şirketi'nin Ocak 2013- Ocak 2014 tarihleri arasında istatistiksel verilerinin analiz edilmesini, Şirket'in üretim seviyesini tahmin edebilmek için en iyi tahminleme yönteminin bulmasını ve Şirket'in önümüzde ki 52 hafta için tahminlemesinin yapılarak şirketin sipariş vermesi gereken uygun hammadde miktarını bulunmasını amaçlamaktadır.

Çalışmada, Trend Analizi, Ayrıştırma Yöntemi, Ağırlıklı Ortalama, (Single Exponential Method) ve Winter Yöntemi gibi çeşitli tahminleme yöntemleri için MİNİTAB yazılımı kullanılmıştır.

En önemli kalemin envanter kontrol seviyesine bakıldığında bu ürünün sürekli kontrol sistemine ihtiyaç duyduğu görülmüştür. Örnek olarak, eldeki envanter miktarı belli bir seviyeye düştüğünde envanter seviyesini sabit bir miktara çıkarmak amacıyla yeniden sipariş verilmesi, yani yeniden sipariş noktası verilebilir.

Anahtar Kelimeler: Talep Tahmini, ABC Analizi, Envanter Kontrol Noktası.

ABSTRACT

FORECASTING AND INVENTORY CONTROL IN A COMPANY IN IZMIR

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MSc in Industrial Management and Information System

Supervisor: Assoc. Prof. Dr. M. Fatih TAŞGETİREN

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The company in this case is a manufacturer of raw materials. This research aims at analyzing the statistical data of a Company in Izmir from January 2013 to January 2014 and generating the best method to forecast the company's production level, and determining what would be a reasonable Forecast for the next 52 weeks as well as finding out the efficient amount of raw materials for the company to order. Using ABC Analysis, the "A parts" are the highest percentile and the most important item needed in production is Item 88 (Adhesive Pleat) with Reference no. #028313100 chosen as our Case study.

Minitab software was used to determine different forecasting methods: Trend Analysis, Decomposition Method, Moving Average, Single Exponential Method, Double Exponential and Winters' Method. The research results suggest that the company use Decomposition Method as it has the minimum MAD and MSE of the six methods.

The level of inventory control of the most important item shows it requires a continuous control system, where the inventory level should be continuously monitored, i.e., an order should be placed to replenish the stock of inventory for the same constant amount whenever the inventory on hand decreases to a certain level, referred to as the reorder point.

Key words: Demand forecasting, ABC analysis, Inventory control policy.

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At the end, I pray for my dearest grandmother, Late Fatime Sissoko and my beloved father, Late Ibrahim Hassan whom could not witness the successful completion of my studies. I believe Allah has bigger plans for you. You will always remain in my heart. May your gentle soul rest in peace and Aljannah be your final home, Amin.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Preamble

With today's uncertain economy, companies are searching for alternative methods to keep ahead of their competitors by effectively driving sales and by cost reduction. The existence of a similar company or the emergence of a new competitor is one of the threatening factors which could lead to the fall, and maybe the destruction, of a company. Therefore, in order for a company to survive and stay away from destruction, various methods are needed so as not to be swayed by both its old and new competitors. One way is to forecast consumer demand. Managers are always trying to make better estimates of what will happen in the future in the face of uncertainty. Making good estimates is the main purpose of forecasting. This research is based on statistical data collected from Cummins Company 2013 and conducted on the basis to device the best forecasting method to estimate future demand under a given set of future conditions. The forecast by individual item for a specific period helps to have knowledge on materials requirements, trends in material and labor costs, trends in availability of material and labor, maintenance requirements, and plant capacity available for production. As a result, the firm can plan its production schedule and inventories to meet demand at a reasonable cost.

Forecasting primarily deals with future and time i.e. a forecast must be made for some specific point in time, and changing that point generally affects what the forecast will be. It must involve judgments and at the same time information must be gathered on which to base a forecast.. Generally speaking, forecasts are based directly or indirectly on information that is obtained from historical data.

To fit the varied situations in which forecasts are required, a number of methods or techniques have been developed during the last two decades. These can be distinguished into two broad classes:

1. quantitative techniques
2. qualitative techniques

These classifications generally reflects the extent to which a forecast can be based directly on historical data in a mechanical fashion. Those techniques that start with a series of past data values and then, following a certain set of rules, develop a prediction of future values fall into the category of quantitative methods. Situations in which such data is not readily available or applicable and

in which much more management judgment must be inserted are generally best suited to the application of qualitative forecasting methods.

Forecasting is the art of estimating future demand by anticipating what buyers are likely to do under a given set of future conditions. The methods employed in this study are; Trend Analysis, Decomposition, Moving Average, Single Exponential Smoothing, Double Exponential Smoothing and Winters' Methods. Demand forecasting is the activity of estimating the quantity of a product or service that consumers will purchase. Demand forecasting involves techniques including both informal methods, such as educated guesses, and quantitative methods, such as the use of historical sales data or current data from test markets. Demand forecasting may be used in making pricing decisions, in assessing future capacity requirements, or in making decisions on whether to enter a new market.

Because demand behaves in random, irregular movements, in order to develop an effective forecasting process, we need to understand the kind of data we are handling. From our raw data, we first used Minitab software to analyze the 70 most important items needed. Seasonal length of values 2 and 4 were used and different variations recorded. Decomposition Method has the smallest MAD for about 50% of the items followed by Trend Analysis.

1.2 Statement of Objectives

The aim of this study is to screen out the items to determine which is the most important using ABC Analysis relative to demand and price and recommend alternative ways to help reduce the Company's stock outs by providing a more effective forecasting method along with Reorder point model. Our study focused on 53 weeks raw data from January 2013 to January 2014 of 1245 items in the Industry. The data was reduced to 776 items whereby the items not demanded were eliminated. Thus, in the approach of doing so, only 776 items were those needed in the production and 70 out of them i.e. the A parts were considered using ABC Analysis after finding the total demand and cumulative demand relative to demand and price. The first most important item chosen was item 88 and forecasting was made to find error analysis (minimum MAD) and thus determining the service level relative to reorder point and safety stock. The items were then sorted on descending order of demand and using Excel, outliers were found, eliminated and substituted with average of 2 weeks demand.

The study also aims at analyzing the variations that occur between service level and safety stock in forecasting the demand of raw materials in the firm. Sensitivity Analysis was used to determine this service level with a constant, k, safety stock, SS and reorder point, R after finding the average lead time. In addition, an analysis of a reasonable Forecast of 52 weeks demand was made using Minitab software. Forecasting was made and the best method chose was Time Series Decomposition method which has the minimum MAD. This MAD was used to calculate the safety inventory of item 88.

1.3 Justification

The research work justified that decomposition method was the best forecast method used through the decision of time series plot relative to the level of error analysis after we screened the data and justified the relativity when lead time was considered. Accurate forecasting determines how much inventory a firm must keep at various points along its supply chain.

1.4 Significance of Study

This study will help us to have knowledge about the demand and check the best kind of forecasting method required to forecast the demand of the most important item using ABC Analysis and also check variation between service level, reorder point and safety stock. The demand forecasts developed reduces uncertainty and attempt to estimate a reasonable forecast for 52 weeks.

1.5 Scope of Study

This study is primarily based on the statistical data we collected from the production line of the Company 2013. The results and findings might be applicable to other industries which make relative kind of production. Since retail can be unpredictable and competitive, the interest of seeing how forecasting can affect the reorder point led to assist the Company in finding alternative methods to solve their forecasting issues.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction to Forecasting

Forecasting is defined as the art or science of predicting future events (Heizer & Render 2001). Forecasting may involve taking historical data and projecting them into the future with some sort of mathematical model. It may be a subjunctive or intuitive prediction. Or it may involve a combination of these, i.e., a mathematical model adjusted by a manager's good judgment.

Forecasting is the activity of estimating the quantity of a product or service that consumers will purchase. Forecasts are always wrong, though they are necessary to predict future occurrence for an event so as to make adequate and optimal decisions. A forecast of product demand is the basis for most important planning decisions. Planning decisions regarding scheduling, inventory, production, facility layout and design, workforce, distribution, purchasing, and so on, are functions of customer demand (Brown 1959).

2.2 Components of Forecasting Demand

There are different forecasting methods that can assist in predicting the quantity of a product a consumer will purchase. The type of forecasting method to use depends on several factors, including the time frame of the forecast (i.e., how far in the future is being forecasted), the behavior of demand, and the possible existence of patterns (trends, seasonality, and etc.), and the causes of such demand behavior. (Russell & Taylor, 2011)

The priorities of forecast method application are determined according to the forecast time span which is traditionally divided into short-range (1-3 months), mid-range (3 months-2 years) and long-range (more than 2 years). Simple quantitative forecast methods are applied for short- and mid- period of time

(simple moving average and exponential smoothing), while for long-term forecast, regression and econometric models are applied (Clifton, Nguyen & Nutt, 1998).

2.3 Forecasting Methods

The forecast method is defined as a way of forecasting task solution or forecast development that guarantees the identification of the way out of different forecast users. The main objective of the forecast method is to transfer the current information into the future and move from the processed information to forecast (Bails & Peppers 1993).

(Bolt 1994, Peterson & Lewis 1999, Cox & Loomis 2001) stated that depending on the research area and research object, the most commonly used forecast method classification is based on the following criteria:

a. Type of information (quantitative and qualitative forecast methods)

b. Forecast time-span (short-term, mid-term and long-term forecast development methods)

c. Forecast object (micro and macro-economic indicator forecast methods)

d. Forecast goal (genetic and normative forecast methods)

The most popular and universal, and the most commonly applied in research papers is the classification based on quantitative and qualitative forecast methods because of its characteristic to involve the methods classified in other groups. (Peterson & Lewis 1999). There are three basic approaches to generating forecasts: time series models, regression *(causal)* forecasting methods and qualitative methods.

2.3.1 Time Series Methods

Box & Jenkins (1976) stated that time series methods are statistical techniques that use historical demand data accumulated over a period of time.

Time series methods assumed that what has occurred in the past will continue to occur in the future. These methods also assumed that identifiable historical patterns or trends for demand over time will repeat themselves. They include the moving average, exponential smoothing, and linear trend line; and they are among the most popular methods for short-range forecasting among service and manufacturing industries.

In a 2007 survey of firms across different industries conducted by the Institute of Business Forecasting, over 60% of the firms used time series models, making up the most popular forecasting method by far. One of the reasons time series models are so popular is that they are relatively easy to understand and use. The survey also showed that the most popular time series models are: moving averages and exponential smoothing. (C.L. Jain 2005-06)

- Linear Trend Analysis

Trend process relies primarily on historical data to predict the future. The analysis involves searching for a right trend equation that will suitably describe trend of the data series. The trend may be linear, or it may not. A linear trend can be obtained by using a least-square method. The line has the equation;

$$y = a + bt \qquad (1)$$

where

t = 1, 2, 3, ...

b = slope of the line

a = value of t=0

To forecast when trend is present, we need to estimate the constant and the slope; there are many ways to do so, including regression and variations on moving averages and exponential smoothing.

- Moving Average

A time series forecast can be as simple as using demand in the current period to predict demand in the next period. This is sometimes called a naive or intuitive forecast. The simple moving average uses several demand values during

the recent past to develop a forecast. This tends to dampen or smooth out, the random increases and decreases of a forecast that uses only one period. The simple moving average is used for forecasting demand that is stable and does not display any pronounced demand behavior, such as a trend or any seasonal pattern.

$$MA_{n=}\frac{\sum_{i=1}^{n} D_i}{n} \qquad (2)$$

where

$n = number\ of\ periods\ in\ the\ moving\ average$

$D_i = demand\ in\ period\ i$

- Time Series Decomposition

Decomposition stands out as one of the most common statistical forecasting methods. When underlying data is broken down into sub patterns to identify the component factors that influence each of the values in series, this procedure is called decomposition. The decomposition model assumes that the data has the following form:

$$Data\ =\ Pattern\ +\ Error$$

$$Data\ = f(\text{trend} - \text{cycle}, \text{Seasonality}, \text{error})$$

Mathematical representation of the decomposition approach is:

$$Y_t = f(S_t, T_t, E_t) \qquad (3)$$

where

Y_t is the time series value (actual data) at period t.

S_t is the seasonal component (index) at period t.

T_t is the trend cycle component at period t.

E_t is the irregular (remainder) component at period t.

Assuming an additive decomposition, the decomposed time series can be written as:

$$y_t = \hat{S}_t + \hat{A}_t \quad (4)$$

where

$\hat{A}_t = \hat{T}_t + \hat{E}_t$ is the seasonally adjusted component.

Or if a multiplicative decomposition has been used, we can write:

$$y_t = \hat{S}_t \hat{A}_t \quad (5)$$

where

$\hat{A}_t = \hat{T}_t \hat{E}_t$.

To forecast a decomposed time series, we separately forecast the seasonal component, $\hat{S}_t$, and the seasonally adjusted component $\hat{A}_t$. It is usually assumed that the seasonal component is unchanging, or changing extremely slowly, and so it is forecast by simply taking the last year of the estimated component.

- Single Exponential Smoothing

Exponential smoothing is also an averaging method that weights the most recent data more strongly. As such, the forecast will react more to recent changes in demand. This is useful if the recent changes in the data are significant and unpredictable instead of just random fluctuations (for which a simple moving average forecast will suffice). Exponential smoothing is one of the more popular and frequently used forecasting techniques, for a variety of reasons. Exponential smoothing requires minimal data. Only the forecast for the current period, the actual demand for the current period, and a weighted factor called a smoothing constant are necessary. The mathematics of the technique is easy to understand by management (Gardner 1985).

$$F_{t+1} = \alpha D_t + (1 - \alpha) F_t \quad (6)$$

where

F_{t+1} = the forecast for the next period

D_t = actual demand in the present period

F_t = the previously determined forecast for the present period

α = a weighing factor referred to as the smoothing constant

Using exponential smoothing, the forecast for the next period is equal to the forecast of the current period, plus a proportion (α) of the forecast error in the current period.

- Double Exponential Smoothing

Also known as Holt exponential smoothing- is a refinement of the popular simple exponential smoothing model but adds another component which takes into account any trend in the data. Simple exponential smoothing models work best with data where there are no trend or seasonality components to the data. When the data exhibits either an increasing or decreasing trend over time, simple exponential smoothing forecasts tend to lag behind observations. Double exponential smoothing is designed to address this type of data series by taking into account any trend in the data.

There are two equations associated with Double Exponential Smoothing.

$$f_t = \alpha . Y_t + (1 - \alpha)(f_{t-1} + b_{t-1}) \quad (7)$$

$$b_t = \gamma . (f_t - f_{t-1}) + (1 - \gamma) . b_{t-1} \quad (8)$$

where:

Y_t is the observed value at time t

f_t is the forecast at time t

b_t is the estimated slope at time t

α is the first smoothing constant, used to smooth the observations
γ is the second smoothing constant used to smooth the trend

- Winters' Method

One more complex form of smoothing that deserves at least brief mention was developed by Winters in the early sixties. His model produces results similar to double exponential smoothing, but it has the extra advantage of incorporating a seasonal coefficient and can therefore be used to predict a data series that combines a trend and a seasonal pattern (Brown 1963). The mathematical model is:

$$x_t = (a + b_t)F_t + \varepsilon_t \quad (9)$$

$\alpha, \beta, \gamma = smoothing\ constants$

2.3.2 Regression Methods

Regression (or causal) forecasting methods attempt to develop a mathematical relationship (in the form of a regression model) between two or more variables i.e., demand and factors that cause it to behave the way it does (Chambers, Satinder et al 1971). If there is no time lag between dependent and independent variables, i.e., they occur in the same time period, we cannot forecast future values of the dependent value unless we use a forecast of the independent variable, which may introduce additional error in the forecast of the dependent variable. Let Y be the quantity to be forecasted and $(X_1, X_2 \ldots . X_n)$ are n variables that have predictive power for Y.

A causal model is:

$$Y = f(X_1, X_2 \ldots . X_{n)} \quad (10)$$

A typical relationship is a linear one:

$$Y = A_0 + A_1X_1 + \cdots + A_nX_n \quad (11)$$

Be very careful using causal models. Often, the cause and effect relationship is not clear, but a causal model is used anyway. (Barron & Targett 1985) discussed a case in Britain where passenger miles flown by a major airline were forecasted by a causal model with United Kingdom manufacturing production as the independent value. Statistically the model "fit" well, but after several months of good forecasts, the results became unusable. There was no causal relationship; manufacturing production did not cause airlines to be flown. The model fit because both variables increased during good economic times. The model failed when the economy worsened and manufacturing production dropped, which indicated a decrease in passenger miles flown. At the same time, the value of the dollar dropped relative to the pound while many Britons flew to the United States for holidays, increasing the number of passenger miles flown.

If we know that something caused demand to behave in a certain way in the past, we would like to identify that relationship so if the same thing happens again in the future, we can predict what demand will be. The simplest form of regression is linear regression that relates one variable, called an independent variable, to another, the dependent variable, in the form of an equation for a straight line. A linear equation has the following general form:

$$Y = A + Bx \tag{12}$$

Where:

Y= the dependent variable

A= the intercept

B= the slope of the line

x= the independent variable

2.3.3 Qualitative Method

Qualitative methods also known as judgmental method use management judgment, expertise, and opinion to make forecasts. Often called "the jury of executive opinion," they are the most common type of forecasting method for the long-term strategic planning process. There are normally individuals or groups in an organization whose judgments and opinions regarding the future are as valid as or more valid than those of outside experts or structured approaches. Top managers are the key group involved in the development of forecasts for strategic plans. (Makridakis et al 1983).

According to Tersine & Riggs (1976), the Delphi method is a procedure for acquiring informed judgments and opinions from knowledgeable individuals using a series of questionnaires to develop a consensus forecast about what will occur in the future. Although the Delphi method has been used for a variety of applications, forecasting has been one of its primary uses. It has been especially useful for forecasting technological change and advances.

2.4 Forecast Accuracy

A forecast is never completely accurate; forecasts will always deviate from the actual demand. This difference between the forecast and the actual is the forecast error. Although forecast error is inevitable, the objective of forecasting is that it be as slight as possible. A large degree of error may indicate that either the forecasting technique is the wrong one or it needs to be adjusted by changing its parameters.

The forecast error is the difference between the actual demand and the forecast value for the corresponding period. It is mathematically represented as:

$$E_t = D_t - F_t \tag{13}$$

2.5 Measuring Forecast Errors

There are several commonly used methods to calculate forecast errors (Heizer & Render 2001). These methods can be used to compare different forecasting models, as well as to oversee the forecasting process itself to ensure that it goes well. Three of the most famous methods are: Mean Absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percent Error (MAPE).

2.5.1 Mean Absolute Deviation (MAD)

MAD is the first measure of the entire forecast errors of a model. This value is calculated by dividing the sum of the absolute value of forecast errors with the number of periods of data (n).

$$MAD = \frac{\sum |D_t - F_t|}{n} \tag{14}$$

where

$t =$ the period number

$D_t =$ demand in period t

$F_t =$ the forecast for period t

n = the total number of periods

|| = the absolute value

2.5.2 Mean Squared Error (MSE)

MSE is the second method used in measuring entire forecast errors. MSE is the average squared differences between the observed and predicted values. Its formula is:

$$MSE = \frac{\sum (Forecast\ errors)^2}{n} \tag{15}$$

The drawback of using the MSE is that it tends to accentuate large deviations due to the squared term. For example, if the forecast error for period 1 is twice as large

as the error for period 2, the squared error in period 1 is four times as large as that for period 2. Hence, using MSE as the measure of forecast error typically indicates that we prefer to have several smaller deviations rather than even one large deviation.

2.5.3 Mean Absolute Percentage Error (MAPE)

A problem with both MAD and MSE is that their values depend on the magnitude of the item being forecast. If the forecast item is measured in thousands, its MAD and MSE values can be very large. To avoid this problem, we can use MAPE, which is the average of the absolute difference between the observed and predicted values, expressed as a percentage of the actual values. It is mathematically represented as:

$$MAPE = \frac{\sum_{i=1}^{n} 100\,|A_t - F_t|/A_t}{n} \qquad (16)$$

Where $A_t$is the actual value and F_t is the forecast value.

The difference between A_t and F_t is divided by the Actual value $A_t$again. The absolute value in this calculation is summed for every fitted or forecasted point in time and divided again by the number of fitted points n. multiplying by 100 makes it a percentage error.

$$MSE^{0.5} = 1.25\,MAD = S_{error} \qquad (17)$$

2.6 Forecast Control

There are several ways to monitor forecast error over time to make sure that the forecast is performing correctly, i.e., the forecast is in control. Forecasts can go "out of control" and start providing inaccurate forecasts for several reasons, including a change in trend, the unanticipated appearance of a cycle, or an irregular variation such as unseasonable weather, a promotional campaign, new competition, or a political event that distracts consumers (Russell & Taylor 2011).

A tracking signal indicates if the forecast is consistently biased high or low. It is computed by dividing the cumulative error by MAD. The tracking signal is recomputed each period, with updated, "running" values of cumulative error and MAD. The movement of the tracking signal is compared to control limits; as long as the tracking signal is within these limits, the forecast is in control. The tracking signal is computed as the cumulative error divided by the mean absolute deviation(MAD):

$$\text{Tracking signal} = \frac{\text{Cumulative error}}{\text{MAD}}$$

$$= \frac{\sum(\mathrm{A_t} - \mathrm{F_t})}{\text{MAD}} \qquad (18)$$

where

$$MAD = \frac{\sum |A - F|}{n}$$

Another method for monitoring forecasting error is statistical control charts.

2.7 Reorder Point, Safety Stock and Service Level

The ROP quantity reflects the level of inventory that triggers the placement of an order for additional units (Fangruo 1998). It is assumed that a firm will place an order when the inventory level for that particular item reaches zero and that it will receive the ordered items immediately. However, the time between the placement and receipt of an order, called lead time, or delivery time, can be as short as a few hours or as long as months. Thus, the when-to-order decision is usually expressed in terms of a reorder point(ROP)- the inventory level at which an order should be placed.

The reorder point(ROP) is given as:

$$ROP = (Demand\ per\ day) \times (Lead\ time\ for\ a\ new\ order\ in\ days)$$

$$= d \times L \qquad (19)$$

This equation for ROP assumes that demand during lead time and lead time itself are constant. When this is not the case, extra stock, often called safety stock, should be added.

The demand per day, d, is found by dividing the annual demand, D by the number of working days in a year:

$$d = \frac{D}{\text{Number of working days in a year}} \qquad (20)$$

.Safety stock known as "buffer" is the standard deviation of demand during lead time. Lead time is the time interval from placing an order until receiving the order. Thus, reorder point is connected with the lead time and the order quantity as a function of time as can be seen in the graph below:

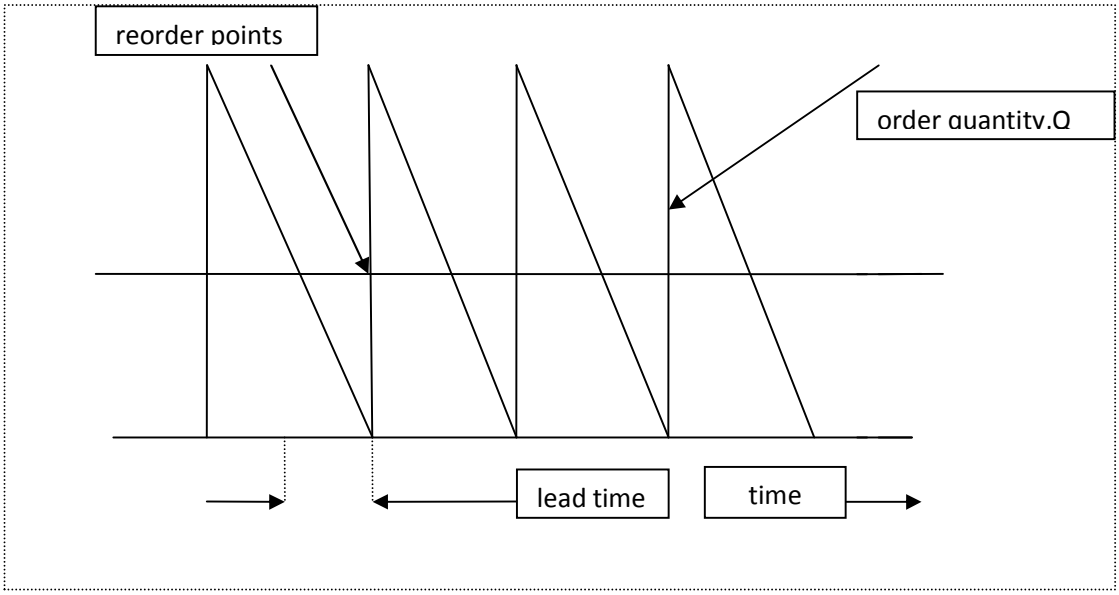

Figure 2.1 Graph illustrating safety stock, lead time and reorder point

In determining the reorder point the following three factors need to be at hand:

a. Demand- Quantity of inventory used or sold each day

b. Lead Time- Time [in days] it takes for an order to arrive when an order is placed

c. Safety Stock- The quantity of inventory kept on hand in case there is an unpredictable event like delays in lead time or unexpected demand.

2.8 Inventory Control Systems

2.8.1 The Role of Inventory

Inventory is a quantity of commodity in the control of an enterprise, held for some time to satisfy some future demand. It is a "buffer" between two processes- supply and demand. The supply process contributes commodity to the inventory, whereas demand depletes the same inventory. Inventory is necessary because of differences in rates and timing between supply and demand, and this difference can be attributed to both internal and exogenous factors. Internal factors are a matter of policy, but exogenous factors are uncontrollable. Among the internal factors are

- Economies of scale
- Operation smoothing
- Customer service
- Uncertainty

For manufacturing sector, the commodity is principally materials: raw material, purchased items, semi-finished and finished products, spare parts, and supplies.

2.8.2 Inventory Policies

The major element impacting inventory is demand. From the production control stand point, it is assumed demand is an uncontrolled variable. Thus there are important factors in an inventory system called decision variables that can be controlled by determining how much to order (the level of replenishment), i.e.,

quantity decision and when to order (timing decision). There are two basic types of inventory systems:

- Periodic Review Policy

Inventory on hand is counted at specific time intervals, for example, every week or at the end of each month. After the inventory in stock is determined, an order is placed for an amount that will bring inventory back up to a desired level. In this system, the inventory system is not monitored at all during the time intervals between orders. At fixed time intervals, check the inventory level, and issue an order if the inventory level is below a certain predetermined level called the reorder point (timing decision). The size of the order is the amount required to bring the inventory to a predetermined level (quantity decision). The size of order varies from period to period. This order is often referred to as a periodic policy or fixed order interval policy (Bellman, Elicksberg & Gross 1955)

- Continuous Review Policy

In this policy, the level of inventory is continuously monitored, so management knows the inventory status. When the inventory reaches the reorder point (timing decision), a fixed quantity is ordered (quantity decision) to replenish the stock of inventory. The order that is placed is for a fixed amount that minimizes the total inventory cost. This is a continuous policy, or a fixed reorder quantity policy. (Hadley & Whitin 1963)

CHAPTER THREE

3.0 MODEL EMPLOYED

3.1 Data Analysis

The case study considered is the demand data for items used in the production department of a Company in Izmir. The data was obtained with the objective to see the item behavior due to its demand to help establish a forecasting trend for the most important item(s). The data on item demand was provided by the company from January 2013 to January 2014 which included 1245 items with their reference numbers, descriptions, statuses, 53 weeks demands, quantities, transaction dates, etc.

In the analysis, three steps were followed; First method was emphasizing the effect of ABC Analysis to choose the most important item(s) needed for production. Second was generating best forecasting method by plotting the demand to see the trends of each of the important item(s). The forecast methods used includes; Trend Analysis, Moving Averages, Decomposition, Single Exponential Smoothing, Double Exponential and Winters' method. The third step was establishing the variations that exist between the service levels, k, relative to safety stock and reorder point.

3.2 ABC Analysis

The ABC system is a method of classifying inventory according to several criteria, including its dollar value to the firm. Typically, thousands of independent demand items are held in inventory by a company especially in manufacturing, but a small percentage is of high dollar value to warrant close inventory control. In general, about 5 to 15% of all inventory items account for 70 to 80% of the total dollar value of inventory. These are classified as A, or Class A, items. B items represent approximately 30% of total inventory units but only about 15% of total dollar value. C items generally account for 50 to 60% of all inventory units but represent only 5 to 10% of total dollar value. From the raw data of 1245 items given, the items demanded were sorted out according to the demand and cost importance through the ABC analysis technique. The data was put together, and demand was arranged in descending order, and cumulative percentage was found. Using the ABC analysis, the highest percentile was chosen as our case study in this research, i.e., 70% out of the items (A parts) were chosen which included the most important items demanded in the firm. The demand was plotted for each of the 77 items which showed their previous demand behavior. Item 88 (Adhesive

Pleat) happened to be the most important item in the company, it has a Reference no. of 28313100 and it was 99191.69% needed in the company for production. Seventy items were chosen from Cummins Company that were considered to be high revenue level items.

3.3 Forecasting Methods

The main variable in this study is to forecast customer demand for items. Forecasting was analyzed using Minitab Software particularly with Trend Analysis, Moving Average, Decomposition, Exponential Smoothing and Winter's method. We looked at 2-4 seasonal length and how each forecasting period varied due to the amount of periods used. Also, MAD, MSE and MAPE were determined. Out of these methods, the best one is with the small forecast error (minimum MAD).

3.4 Finding Outliers Using Excel

To find the Outliers (unusually large or small observations that may or may not be explained), we found the Average and Standard deviation of forecasted Demand, the minimum and maximum values and then computed them using excel, eliminated and replaced over again by the average of the cell in between on the spreadsheet.

3.5 Computing Reorder Point

To compute the reorder point with a safety stock that will meet a specific service level, annual demand and lead time was taken into consideration. The lead time is the number of days it takes to receive the product when an order is placed. We generated a random lead time and made a forecasting for lead time. Safety inventory was calculated.

CHAPTER FOUR

4.0 COMPUTATIONAL ANALYSIS

4.1 ABC Analysis

Using the ABC Analysis, we classified all the items as either A, B, or C but our case study is to determine the level of inventory control for Class A items. The first 70 out of 776 are the most important items considered and are those with the highest percentile. Class A items require tight inventory control because they represent such a large percentage of the total dollar value of inventory. This inventory level should be as low as possible, and safety stock minimized. This requires accurate demand forecasts and detailed record keeping. In general, A items frequently require a continuous control system, where the inventory level is continuously monitored; a periodic review system with less monitoring will suffice for C items. The ABC Analysis is shown in Appendices.

4.2 Forecast Analysis

The choice of forecast was based on finding the minimum forecast error for the different items that composed the A parts. Different forecasting method was used with 2 and 4 seasonal length and we monitor forecast error. Decomposition method has the minimum MAD's when moving length of 4 was used, then trend Analysis, Single exponential and double then winter.

Table 4.2 Different Forecasting Methods Employed

S/N	ITEMS	A	B	C	D	E	F	G	H	I
1	88	4758	4680	4688	5354	5638	5078	4962	6336	6875
2	461	1800	1788	1759	1961	2026	1739	1766	2259	2530
3	463	1506	1498	1514	1704	1887	1585	1637	2100	2279
4	246	1257	1262	1220	1227	1204	1130	1150	-	-
5	244	846	850	847	1047	1003	893	945	1017	1015
6	89	719	719	712	895	898	810	804	1034	1076
7	375	590	578	572	706	649	600	717	706	780
8	462	950	933	922	1042	1021	916	982	1026	1115
9	239	1015	996	980	993	810	765	822	-	-
10	238	885	879	889	722	770	759	740	758	819
11	253	415	416	416	535	501	441	476	500	503
12	108	467	463	452	644	555	471	626	585	565
13	245	821	821	1219	544	601	599	559	702	738
14	115	502	499	499	550	583	508	542	619	658
15	57	602	612	1923	634	619	627	655	777	1048
16	395	527	509	511	563	585	541	519	597	620
17	42	635	635	672	689	699	612	663	726	843

Table 4.2 Different Forecasting Methods Employed(continued)

S/N	ITEMS	A	B	C	D	F	G	H	I	J
18	127	494	496	490	496	498	476	477	553	566
19	474	506	498	481	536	548	522	491	584	667
20	473	506	498	481	536	548	522	491	584	667
21	452	231	231	235	299	287	242	277	291	291
22	250	223	224.1	220.2	294	268	239	267	266	267
23	243	223.0	224.1	220.2	294	268	239	267	266	267
24	249	209.5	210.2	209.6	269	248	224.2	238	250	252
25	188	336	338	298	382	350	330	357	392	404
26	257	207.8	208.7	209.2	269	251	219.8	232	252	253
27	240	207.5	208.3	208.8	268	250	219.0	238	252	252
28	254	207.5	208.2	207.8	267	251	220.3	238	250	252
29	470	217.2	217.4	216.2	271	247	222.0	235	249	248
30	258	207.5	208.2	207.8	267	251	220.3	238	250	252
31	260	218.2	218.8	213.0	276	255	225.6	232	255	252
32	241	221.0	221.2	216.2	277	258	228.2	234	257	254
33	453	218.5	219.1	213.2	276	255	226.0	233	256	252
34	248	261	259	254	284	276	265	266	278	280
35	516	130.1	122.8	121.1	136.5	141.9	133.5	139.0	166.8	181.5
36	517	131.5	132.1	132.9	162.0	155.2	128.9	157.2	151.8	159.5
37	624	225.8	225.5	223.9	260	246	230.9	230	244	244
38	256	227.6	226.5	223.5	268	255	231.8	235.4	255	255
39	189	288	287	283	372	325	291	354	359	370
40	518	184.5	185.9	181.6	187.4	188.5	184.4	199.2	220.8	238.2
41	440	372	374	603	397	386	389	401	476	576
42	491	324	332	327	372	353	351	376	544	503
43	405	384	385	386	396	397	360	359	434	462
44	252	244	240.4	237.1	253	247	241	233	248	245
45	139	376	380	395	396	387	375	360	437	449
46	496	372	370	401	393	398	372	355	418	472
47	497	470	397	369	393	396	375	355	417	469
48	378	441	389	911	499	481	439	466	548	611
49	59	320	322	315	297	299	317	312	344	349
50	118	276	280	274	364	326	279	374	358	338
51	502	450	405	-	503	503	464	491	591	596
52	398	450	405	-	503	503	464	491	591	596
53	501	449	404	-	503	502	463	492	592	595
54	500	350	350	353	400	378	-	366	-	-
55	465	350	350	353	400	378	-	366	-	-
56	167	297	384	301	363	335	305	371	365	357
57	373	165.7	167.4	166.2	228.4	192.8	169.2	205.5	202.0	196.8

Table 4.2 Different Forecasting Methods Employed(continued)

S/N	ITEMS	A	B	C	D	F	G	H	I	J
58	382	337	297	290	383	365	356	377	378	478
59	320	339	295	288	385	365	358	359	387	481
60	270	339	295	288	385	365	358	359	387	481
61	380	333	336	333	380	394	-	379	-	-
62	428	218.9	219.6	226.9	284	257	227.7	278	273	277
63	156	297	312	447	325	316	311	339	397	419
64	131	297	312	447	325	316	311	339	397	419
65	168	330	329	274	338	328	315	321	361	422
66	160	274.5	270.8	279	330	300	280	332	319	350
67	140	272.3	268.5	267	329	299	278	331	319	348
68	418	284	284	286	295	280	294	314	368	409
69	486	283	283	284	294	280	293	313	368	408
70	485	283	283	284	294	280	293	313	368	408
71	379	368	301	379	378	396	369	369	-	-

where:

A= Trend Analysis

B= Decomposition (using seasonal length of 2)

C= Decomposition (using seasonal length of 4)

D= Moving Average (using seasonal length of 2)

E= Moving average (using seasonal length of 4)

F= Single Exponential Smoothing

G= Double Exponential Smoothing

H= Winter's method (using seasonal length of 2)

I= Winter's method (using seasonal length of 4)

Item 88 being the most important item needed in the company, we forecasted the 53 weeks demand and analysis was made using Minitab Software;

Table 4.3 Fifty-three weeks Forecasted demand for item 88

Weeks	Forecasted Demand
1	15599.6
2	17569.5
3	15495.9
4	17452.3
5	15392.1
6	17335.1
7	15288.4
8	17217.9
9	15184.7
10	17100.6
11	15081.0
12	16983.4
13	14977.2
14	16866.2
15	14873.5
16	16749.0
17	14769.8
18	16631.8
19	14666.1
20	16514.6
21	14562.4
22	16397.4
23	14458.6
24	16280.2
25	14354.9
26	16163.0
27	14251.2
28	16045.8
29	14147.5
30	15928.6
31	14043.7
32	15811.3
33	13940.0
34	15694.1
35	13836.3
36	15576.9
37	13732.6
38	15459.7
39	13628.9
40	15342.5
41	13421.1
42	15225.3

Table 4.3 Fifty-three weeks Forecasted demand for item 88(continued)

Weeks	Forecasted Demand
43	13421.4
44	15108.1
45	13317.7
46	14990.9
47	13214.0
48	14873.7
49	13110.2
50	14756.5
51	13006.5
52	14639.2
53	12902.8

Total forecasted demand= 803495.7

Average forecasted demand, $\overline{D}$ = *Total forecasted demand/53 weeks*

$$\overline{D} = 803495.7 \div 53$$

$$\overline{D} = 15160.29$$

4.3 SAFETY STOCK ANALYSIS

4.3.1 Continuous Review Policy

The appropriate inventory control policy to be selected was the continuous (fixed order quantity system) when inventory reaches a specific level, referred to as the reorder point, a fixed amount should be ordered. Safety stock, a buffer added to the inventory on hand during lead time such that the new order quantity will arrive at exactly the same moment as the inventory level reaches zero. We used the formula;

$$SS = K\sqrt{L} \times \sigma_1$$

$$r = L \times \overline{D} + SS$$

where;

SS = Safety Stock

k= Service level (constant)

L= Average lead time

$\overline{D}$= Average Forecasted demand

σ_1= Standard deviation of demand ($= 1.25 \times MAD$)

The service level is the probability that the inventory available during lead time will meet demand.

thus:

$$k = 0.90 - 0.99$$

$$L = 1.868$$

$$\sigma_1 = 1.25 \times 4680 = 5850$$

Therefore; $SS = 0.90 \times \sqrt{1.868} \times 5850 = 7195.93$

$$r = (1.868 \times 15160.29) + 7195.93 = 35515.35$$

Table 4.4 Randomly Generated 52 weeks Lead time for item 88

Weeks	Lead times	Weeks	Lead times	Weeks	Lead times	Weeks	Lead times
1	1	14	3	27	2	40	3
2	1	15	2	28	1	41	2
3	3	16	1	29	2	42	1
4	1	17	2	30	3	43	2
5	1	18	2	31	1	44	1
6	1	19	2	32	2	45	3
7	2	20	1	33	1	46	2
8	1	21	2	34	2	47	2
9	2	22	1	35	1	48	2
10	2	23	3	36	2	49	1
11	1	24	3	37	2	50	2
12	1	25	2	38	1	51	2
13	2	26	3	39	2	52	1

$$\text{Average lead time} = 1.868$$

$$\text{Sum} = 97$$

After randomly generating the lead times for item 88, the average lead time was calculated and forecasting for lead time was made.

Average 53 weeks forecasted demand of item 88 is 15160.29

Standard deviation of demand was calculated using:

$$= 1.25 \times \text{MAD or } \sqrt{\text{MSE}}$$

$$= 1.25 \times 4680$$

$$= 5850$$

The service level, k is constant and we use the value of;

$$\text{k} = 0.90, 0.91, \ldots 0.99$$

$$\text{Average forecasted Leadtime} = 1.868$$

$$\text{Safety stock} = 7195.93$$

$$\text{Reorder point} = 35514.81$$

Safety stock and reorder point was calculated when using the service level for the k values, $0.91 - 0.99$,

$$\text{SS} = 0.90 \times \sqrt{1.868} \times 5850 = 7195.92$$

$$\text{SS} = 0.91 \times \sqrt{1.868} \times 5850 = 7275.88$$

$$\text{SS} = 0.92 \times \sqrt{1.868} \times 5850 = 7355.84$$

$$\text{SS} = 0.93 \times \sqrt{1.868} \times 5850 = 7435.79$$

$$\text{SS} = 0.94 \times \sqrt{1.868} \times 5850 = 7515.75$$

$$\text{SS} = 0.95 \times \sqrt{1.868} \times 5850 = 7595.70$$

$$\text{SS} = 0.96 \times \sqrt{1.868} \times 5850 = 7676.66$$

$$\text{SS} = 0.97 \times \sqrt{1.868} \times 5850 = 7755.61$$

$$\text{SS} = 0.98 \times \sqrt{1.868} \times 5850 = 7835.57$$

$$SS = 0.99 \times \sqrt{1.868} \times 5850 = 7919.52$$

4.3.2 Service level Exchange Curve

In the following table, we've listed the reorder point and safety stock levels corresponding to service level between 90% and 99%.

Table 4.5 Safety Stock and Reorder Point levels corresponding to service levels between 90% & 99%

S/N	Service level, k (%)	Safety Stock	Reorder point
1	90	7195.92	35515.81
2	91	7275.88	35594.76
3	92	7355.84	35674.72
4	93	7435.79	35754.67
5	94	7515.75	35834.63
6	95	7595.70	35914.58
7	96	7675.66	35994.54
8	97	7755.61	36074.49
9	98	7835.57	36154.45
10	99	7915.52	36234.40

Figure 4.1 Graph on Safety stock and Service level

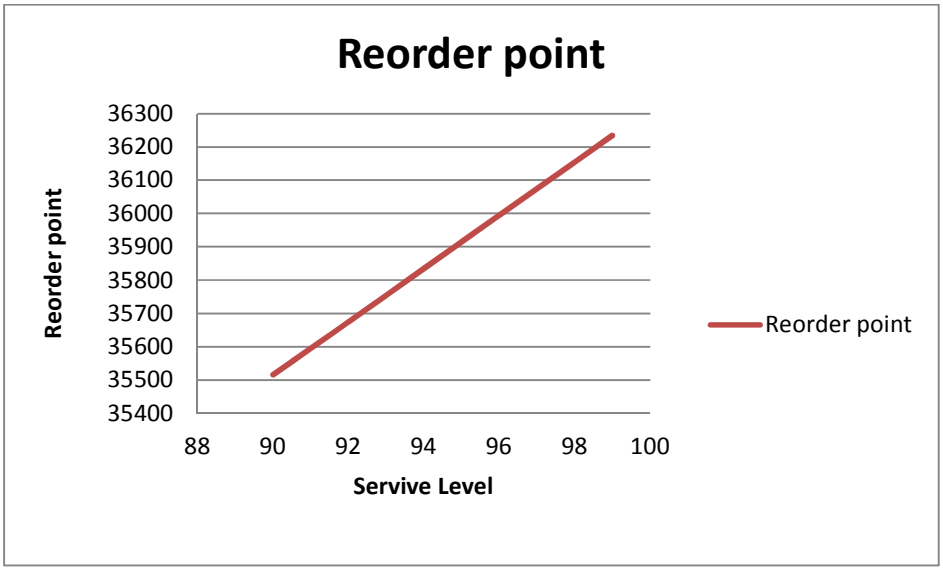

Figure 4.2 Graph on Reorder Point and Service level

Reorder point and Safety stock was increased when service level is increased. We noticed that moving from 90% to 99% service level increases the reorder point and thus the safety stock.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

An essential aspect of managing any organization is planning for the future. Forecasts of product demand are a necessity for almost all aspects of operational planning. The first step taken after collecting the statistical data was the ABC Analysis to sort the demand in descending order of annual dollar usage per item. Item 88 (Adhesive Pleat) was found to be the most important item needed in the production. Forecast was made using all the different methods and based on the forecast of the demand level for fifty-two weeks generated, it was observed that the best method to determine the demand level of items in the company was Decomposition Method as it has the smallest MAD and MSE values. We proceeded with the computation of the safety stock. When the constant service level, k with values 0.9-0.99 was used, there was an increase in safety stock and reorder point. We can also attain a 90% service level with a reorder point less than our mean lead time demand. The primary item was item 88 (Adhesive Pleat), and should be purchased in the right amount to keep the production process going well. The calculation indicates that the company has to keep 7195.92 unit of Adhesive Pleat in order to meet consumer demand.

5.2 RECOMMENDATION

From this case study, the numerous methods of forecasting techniques useful for different time frames are easy to understand, simple to use and not especially costly unless the data requirements are substantial. Effective forecasting method can be used to analyze this kind of related data by examining sample of series. In terms of demand forecasting, it is recommended for the Company to use Decomposition Methods as this research has shown it has the smallest forecast error. By using the amount computed in the forecast, the company would be able to meet consumer demand and can avoid the huge inventory costs as all products will be delivered to consumers within a short time. The company's manufacturing department can use the forecasted demand for short-term inventory and long-term planning. In the short term inventory planning, forecasts can be used as an input to the MRP system (including labor and material). In the long run resource planning, they can be used for determining manpower and requirements for plant and equipment necessary for future operations.

5.3 APPENDICES

Appendix 1

Table 1: ABC Analysis

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
1	88	961014.5	961014.5	17.52583
2	461	375878	1336893	24.38064
3	463	351466	1688359	30.79025
4	246	130542	1818901	33.17092
5	244	116305	1935206	35.29195
6	89	99191.69	2034397	37.10089
7	375	96356.58	2130754	38.85813
8	462	88920	2219674	40.47974
9	239	83768	2303442	42.0074
10	238	61503	2364945	43.12902
11	253	57488	2422433	44.17742
12	108	46531	2468964	45.02599
13	245	41928	2510892	45.79063
14	115	40637	2551529	46.53172
15	57	40588.65	2592117	47.27192
16	395	36816	2628933	47.94333
17	42	36284.55	2665218	48.60504
18	127	33801	2699019	49.22146
19	473	32954	2731973	49.82244
20	474	32954	2764927	50.42342
21	452	30227	2795154	50.97466
22	250	29965	2825119	51.52112
23	243	29824	2854943	52.06502
24	249	29198	2884141	52.5975
25	188	29181	2913322	53.12967
26	257	29162	2942484	53.66149
27	240	29073	2971557	54.19169
28	254	28744	3000301	54.71588
29	470	27860	3028161	55.22396
30	258	27196	3055357	55.71993
31	241	27048	3082405	56.2132
32	260	27048	3109453	56.70647
33	453	27032	3136485	57.19944
34	248	26198	3162683	57.67721
35	516	26094.74	3188778	58.1531
36	517	25427.25	3214205	58.61681

Appendix 2

Table 2: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
37	624	25070	3239275	59.074
38	256	24537	3263812	59.52148
39	189	24350	3288162	59.96555
40	518	23491.54	3311654	60.39396
41	440	23363	3335017	60.82002
42	491	21975	3356992	61.22078
43	405	21046	3378038	61.60459
44	252	21028	3399066	61.98807
45	139	20705	3419771	62.36566
46	496	20568	3440339	62.74076
47	497	20499	3460838	63.1146
48	378	19994	3480832	63.47922
49	59	19967.67	3500799	63.84337
50	118	19388	3520187	64.19694
51	398	17922	3538109	64.52378
52	502	17922	3556031	64.85062
53	501	17890	3573921	65.17688
54	465	17740	3591661	65.5004
55	167	17462	3609123	65.81885
56	373	17290.98	3626414	66.13418
57	382	17265	3643679	66.44904
58	270	17157	3660836	66.76193
59	320	17157	3677993	67.07482
60	380	16588	3694581	67.37733
61	428	15783	3710364	67.66516
62	131	15725	3726089	67.95194
63	156	15725	3741814	68.23871
64	168	15541	3757355	68.52213
65	140	15228	3772583	68.79984
66	160	15228	3787811	69.07755
67	418	13962	3801773	69.33217
68	485	13927	3815700	69.58615
69	486	13927	3829627	69.84014
70	379	13863	3843490	70.09295
71	404	13836	3857326	70.34528
72	67	13704.26	3871030	70.5952
73	391	13626	3884656	70.8437

Appendix 3

Table 3: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMMULATIVE DEMAND	CUMULATIVE %
74	77	13428.73	3898085	71.08859
75	493	13324	3911409	71.33158
76	494	13324	3924733	71.57457
77	455	13185	3937918	71.81502
78	186	12366	3950284	72.04053
79	128	12218	3962502	72.26335
80	266	11936	3974438	72.48103
81	315	11936	3986374	72.6987
82	70	11377.79	3997752	72.9062
83	477	11350	4009102	73.11318
84	187	11345	4020447	73.32008
85	495	11345	4031792	73.52698
86	272	11012	4042804	73.7278
87	321	11012	4053816	73.92862
88	394	11012	4064828	74.12945
89	129	10981	4075809	74.32971
90	130	10875	4086684	74.52803
91	155	10875	4097559	74.72636
92	410	10875	4108434	74.92468
93	503	10831	4119265	75.1222
94	569	10828	4130093	75.31967
95	400	10805	4140898	75.51672
96	117	10612	4151510	75.71025
97	451	10612	4162122	75.90378
98	484	10612	4172734	76.09731
99	91	10267	4183001	76.28454
100	109	10267	4193268	76.47178
101	507	10031	4203299	76.65471
102	508	10031	4213330	76.83765
103	466	10007	4223337	77.02014
104	51	10005.15	4233342	77.20261
105	125	9898	4243240	77.38311
106	798	9846	4253086	77.56267
107	431	9778	4262864	77.74099
108	492	9758	4272622	77.91895
109	430	9754	4282376	78.09683
110	489	9628	4292004	78.27241

Appendix 4

Table 4: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMMULATIVE DEMAND	CUMULATIVE %
111	490	9609	4301613	78.44765
112	53	9505.745	4311119	78.621
113	79	9319.704	4320439	78.79097
114	515	9160	4329599	78.95801
115	570	9160	4338759	79.12506
116	559	9104	4347863	79.29109
117	76	9084.095	4356947	79.45676
118	553	8688	4365635	79.6152
119	116	8543	4374178	79.77099
120	483	8543	4382721	79.92679
121	3	8521	4391242	80.08219
122	439	8463	4399705	80.23653
123	460	8295	4408000	80.3878
124	691	8279.863	4416279	80.5388
125	500	7740	4424019	80.67995
126	479	7054	4431073	80.80859
127	480	7054	4438127	80.93724
128	18	6948.227	4445076	81.06395
129	384	6904	4451980	81.18986
130	148	6808	4458788	81.31401
131	87	6728.88	4465517	81.43673
132	69	6701.604	4472218	81.55894
133	637	6575	4478793	81.67885
134	383	6320	4485113	81.7941
135	107	6286	4491399	81.90874
136	647	6271	4497670	82.0231
137	627	6239	4503909	82.13688
138	628	6239	4510148	82.25066
139	464	6163	4516311	82.36306
140	506	6163	4522474	82.47545
141	227	6145	4528619	82.58751
142	905	6063	4534682	82.69808
143	979	6063	4540745	82.80865
144	487	5945	4546690	82.91707
145	488	5945	4552635	83.02549
146	2	5920	4558555	83.13345
147	138	5871	4564426	83.24052

Appendix 5

Table 5: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
148	209	5776	4570202	83.34586
149	44	5693.887	4575896	83.44969
150	232	5650	4581546	83.55273
151	234	5650	4587196	83.65577
152	281	5650	4592846	83.75881
153	625	5650	4598496	83.86185
154	895	5607	4604103	83.9641
155	969	5576	4609679	84.06579
156	101	5559	4615238	84.16717
157	149	5559	4620797	84.26854
158	233	5537	4626334	84.36952
159	235	5537	4631871	84.4705
160	388	5537	4637408	84.57148
161	467	5537	4642945	84.67245
162	563	5490	4648435	84.77257
163	565	5490	4653925	84.87269
164	564	5486	4659411	84.97274
165	172	5361	4664772	85.07051
166	157	5186	4669958	85.16508
167	163	5186	4675144	85.25966
168	211	5186	4680330	85.35424
169	271	5186	4685516	85.44881
170	319	5186	4690702	85.54339
171	386	5186	4695888	85.63796
172	511	5112	4701000	85.73119
173	512	5112	4706112	85.82442
174	178	5048.231	4711160	85.91648
175	456	4962	4716122	86.00697
176	389	4960	4721082	86.09743
177	450	4953	4726035	86.18775
178	638	4933	4730968	86.27771
179	106	4920	4735888	86.36744
180	121	4658	4740546	86.45239
181	161	4658	4745204	86.53733
182	381	4658	4749862	86.62228
183	498	4658	4754520	86.70723
184	499	4658	4759178	86.79217

Appendix 6

Table 6: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
185	1028	4564	4763742	86.87541
186	459	4553	4768295	86.95844
187	255	4540	4772835	87.04123
188	623	4500	4777335	87.1233
189	122	4360	4781695	87.20281
190	66	4255.518	4785951	87.28042
191	45	4232.192	4790183	87.3576
192	408	4229	4794412	87.43472
193	171	4224	4798636	87.51176
194	878	4205	4802841	87.58844
195	504	4188	4807029	87.66482
196	505	4188	4811217	87.74119
197	626	4139	4815356	87.81668
198	957	4123	4819479	87.89187
199	432	4119	4823598	87.96698
200	226	4105	4827703	88.04185
201	446	4105	4831808	88.11671
202	556	4105	4835913	88.19157
203	557	4105	4840018	88.26643
204	210	4079	4844097	88.34082
205	610	4029	4848126	88.4143
206	134	4019	4852145	88.48759
207	413	3943	4856088	88.5595
208	1116	3861	4859949	88.62991
209	1117	3861	4863810	88.70032
210	173	3807	4867617	88.76975
211	509	3807	4871424	88.83918
212	510	3807	4875231	88.9086
213	716	3761.441	4878992	88.9772
214	78	3639.25	4882632	89.04357
215	26	3627.125	4886259	89.10972
216	421	3626	4889885	89.17584
217	110	3555	4893440	89.24068
218	362	3543	4896983	89.30529
219	314	3539	4900522	89.36983
220	202	3530	4904052	89.4342
221	102	3511	4907563	89.49823

Appendix 7

Table 7: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
222	396	3462	4911025	89.56137
223	449	3421	4914446	89.62376
224	136	3379	4917825	89.68538
225	295	3379	4921204	89.747
226	345	3379	4924583	89.80862
227	401	3379	4927962	89.87025
228	444	3351	4931313	89.93136
229	208	3315	4934628	89.99181
230	214	3315	4937943	90.05227
231	364	3315	4941258	90.11272
232	367	3315	4944573	90.17318
233	469	3271	4947844	90.23283
234	475	3271	4951115	90.29248
235	476	3271	4954386	90.35214
236	629	3271	4957657	90.41179
237	636	3271	4960928	90.47144
238	646	3271	4964199	90.53109
239	124	3192	4967391	90.5893
240	550	3183	4970574	90.64735
241	551	3183	4973757	90.7054
242	468	3168	4976925	90.76317
243	170	3038	4979963	90.81858
244	236	3038	4983001	90.87398
245	307	3038	4986039	90.92938
246	355	3038	4989077	90.98479
247	434	3038	4992115	91.04019
248	442	3038	4995153	91.09559
249	292	3036	4998189	91.15096
250	342	3036	5001225	91.20633
251	339	3010	5004235	91.26122
252	616	2986	5007221	91.31568
253	165	2984	5010205	91.3701
254	176	2984	5013189	91.42451
255	407	2984	5016173	91.47893
256	98	2947	5019120	91.53268
257	554	2947	5022067	91.58642
258	555	2947	5025014	91.64016

Appendix 8

Table 8: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
259	191	2943	5027957	91.69383
260	204	2943	5030900	91.74751
261	365	2943	5033843	91.80118
262	368	2943	5036786	91.85485
263	523	2940	5039726	91.90846
264	447	2880	5042606	91.96099
265	437	2833	5045439	92.01265
266	95	2804	5048243	92.06379
267	154	2804	5051047	92.11492
268	285	2804	5053851	92.16606
269	334	2804	5056655	92.21719
270	46	2712.853	5059368	92.26667
271	513	2690	5062058	92.31573
272	514	2690	5064748	92.36478
273	50	2686.944	5067435	92.41378
274	277	2685	5070120	92.46275
275	326	2685	5072805	92.51171
276	377	2636.879	5075442	92.5598
277	619	2619	5078061	92.60757
278	620	2619	5080680	92.65533
279	36	2617.264	5083297	92.70306
280	113	2614	5085911	92.75073
281	145	2614	5088525	92.7984
282	135	2601	5091126	92.84583
283	543	2589	5093715	92.89305
284	544	2589	5096304	92.94026
285	308	2558	5098862	92.98691
286	438	2558	5101420	93.03356
287	356	2557	5103977	93.08019
288	96	2537	5106514	93.12646
289	97	2537	5109051	93.17273
290	43	2505.936	5111557	93.21843
291	539	2505	5114062	93.26411
292	540	2505	5116567	93.3098
293	519	2448	5119015	93.35444
294	182	2429	5121444	93.39874
295	65	2354.024	5123798	93.44167

Appendix 9

Table 9: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
296	132	2338	5126136	93.4843
297	174	2338	5128474	93.52694
298	385	2338	5130812	93.56958
299	857	2333	5133145	93.61213
300	55	2307.589	5135452	93.65421
301	445	2245	5137697	93.69515
302	164	2230	5139927	93.73582
303	392	2230	5142157	93.77649
304	212	2228	5144385	93.81712
305	435	2219	5146604	93.85758
306	309	2205	5148809	93.8978
307	357	2199	5151008	93.9379
308	283	2155	5153163	93.9772
309	332	2155	5155318	94.0165
310	415	2155	5157473	94.0558
311	63	2154.923	5159628	94.0951
312	73	2138.476	5161767	94.1341
313	47	2137.517	5163904	94.17308
314	393	2079	5165983	94.21099
315	120	2069	5168052	94.24873
316	478	2069	5170121	94.28646
317	150	2067	5172188	94.32415
318	166	2067	5174255	94.36185
319	457	2031	5176286	94.39889
320	40	2019.796	5178306	94.43572
321	146	1971	5180277	94.47167
322	147	1971	5182248	94.50761
323	611	1927	5184175	94.54275
324	612	1927	5186102	94.5779
325	48	1899.318	5188001	94.61253
326	327	1896	5189897	94.64711
327	54	1886.244	5191784	94.68151
328	142	1886	5193670	94.7159
329	278	1886	5195556	94.7503
330	52	1878.324	5197434	94.78455
331	32	1877.282	5199311	94.81879
332	751	1876	5201187	94.853

Appendix 10

Table 10: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
333	472	1842.625	5203030	94.88661
334	162	1807	5204837	94.91956
335	290	1807	5206644	94.95251
336	206	1804	5208448	94.98541
337	225	1804	5210252	95.01831
338	1015	1799	5212051	95.05112
339	1022	1799	5213850	95.08393
340	1036	1799	5215649	95.11674
341	1243	1798	5217447	95.14953
342	1244	1798	5219245	95.18232
343	846	1795	5221040	95.21505
344	613	1774.837	5222815	95.24742
345	1031	1774.35	5224589	95.27978
346	300	1772	5226361	95.31209
347	349	1772	5228133	95.34441
348	853	1767	5229900	95.37663
349	4	1764	5231664	95.4088
350	229	1760	5233424	95.4409
351	296	1760	5235184	95.47299
352	369	1760	5236944	95.50509
353	286	1748	5238692	95.53697
354	335	1748	5240440	95.56885
355	441	1748	5242188	95.60073
356	549	1740	5243928	95.63246
357	548	1738	5245666	95.66415
358	247	1728	5247394	95.69567
359	153	1719	5249113	95.72702
360	259	1709	5250822	95.75818
361	242	1696	5252518	95.78911
362	261	1696	5254214	95.82004
363	454	1696	5255910	95.85097
364	402	1658	5257568	95.88121
365	915	1628	5259196	95.9109
366	986	1628	5260824	95.94059
367	159	1609	5262433	95.96993
368	141	1580	5264013	95.99874
369	621	1561	5265574	96.02721

Appendix 11

Table 11: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
370	622	1561	5267135	96.05568
371	372	1555.489	5268691	96.08405
372	938	1548	5270239	96.11228
373	230	1509.363	5271748	96.1398
374	471	1508.25	5273256	96.16731
375	397	1502	5274758	96.1947
376	13	1470.05	5276228	96.22151
377	72	1469.636	5277698	96.24831
378	303	1464	5279162	96.27501
379	351	1464	5280626	96.30171
380	288	1447	5282073	96.3281
381	337	1447	5283520	96.35448
382	425	1447	5284967	96.38087
383	62	1439.9	5286407	96.40713
384	520	1436	5287843	96.43332
385	521	1436	5289279	96.45951
386	436	1431	5290710	96.48561
387	545	1431	5292141	96.5117
388	546	1431	5293572	96.5378
389	103	1423	5294995	96.56375
390	56	1418.48	5296413	96.58962
391	902	1415	5297828	96.61542
392	829	1398	5299226	96.64092
393	1136	1382	5300608	96.66612
394	1137	1382	5301990	96.69133
395	64	1378.803	5303369	96.71647
396	737	1376	5304745	96.74156
397	426	1324	5306069	96.76571
398	61	1321.852	5307391	96.78982
399	310	1318	5308709	96.81385
400	358	1318	5310027	96.83789
401	420	1310	5311337	96.86178
402	746	1295	5312632	96.8854
403	39	1290.143	5313922	96.90892
404	566	1287.6	5315210	96.93241
405	909	1287	5316497	96.95588
406	983	1287	5317784	96.97935

Appendix 12

Table 12: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
407	99	1275	5319059	97.0026
408	71	1268.07	5320327	97.02572
409	169	1249	5321576	97.0485
410	193	1249	5322825	97.07128
411	289	1249	5324074	97.09406
412	340	1249	5325323	97.11684
413	771	1248	5326571	97.13959
414	894	1247	5327818	97.16234
415	968	1247	5329065	97.18508
416	126	1243	5330308	97.20775
417	529	1238	5331546	97.23032
418	100	1218	5332764	97.25254
419	269	1206	5333970	97.27453
420	318	1206	5335176	97.29652
421	741	1197	5336373	97.31835
422	22	1102.227	5337475	97.33845
423	614	1098	5338573	97.35848
424	414	1086	5339659	97.37828
425	10	1084	5340743	97.39805
426	218	1084	5341827	97.41782
427	301	1084	5342911	97.43759
428	350	1084	5343995	97.45736
429	291	1083	5345078	97.47711
430	341	1083	5346161	97.49686
431	411	1060	5347221	97.51619
432	302	1050	5348271	97.53534
433	338	1050	5349321	97.55449
434	417	1038	5350359	97.57342
435	282	1030	5351389	97.5922
436	331	1030	5352419	97.61098
437	195	1007	5353426	97.62935
438	196	1007	5354433	97.64771
439	299	1007	5355440	97.66608
440	348	1007	5356447	97.68444
441	424	1007	5357454	97.70281
442	1101	1004	5358458	97.72112
443	197	1003	5359461	97.73941

Appendix 13

Table 13: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
444	198	1003	5360464	97.7577
445	294	1003	5361467	97.77599
446	344	1003	5362470	97.79428
447	1040	1002	5363472	97.81255
448	1114	1002	5364474	97.83083
449	1115	1002	5365476	97.8491
450	74	995.5239	5366471	97.86726
451	284	993	5367464	97.88537
452	333	993	5368457	97.90347
453	137	992	5369449	97.92157
454	133	988	5370437	97.93958
455	175	988	5371425	97.9576
456	279	988	5372413	97.97562
457	328	988	5373401	97.99364
458	68	975.551	5374377	98.01143
459	114	961	5375338	98.02895
460	158	961	5376299	98.04648
461	223	961	5377260	98.06401
462	547	961	5378221	98.08153
463	552	961	5379182	98.09906
464	219	957	5380139	98.11651
465	305	957	5381096	98.13396
466	353	957	5382053	98.15141
467	213	956	5383009	98.16885
468	481	952	5383961	98.18621
469	482	952	5384913	98.20357
470	104	951	5385864	98.22091
471	105	951	5386815	98.23826
472	800	937	5387752	98.25535
473	273	936	5388688	98.27242
474	322	936	5389624	98.28948
475	416	936	5390560	98.30655
476	263	876	5391436	98.32253
477	190	868	5392304	98.33836
478	448	868	5393172	98.35419
479	537	868	5394040	98.37002
480	538	868	5394908	98.38585

Appendix 14

Table 14: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
481	541	862	5395770	98.40157
482	542	862	5396632	98.41729
483	38	817.108	5397449	98.43219
484	93	800	5398249	98.44678
485	764	798	5399047	98.46133
486	83	790.136	5399837	98.47574
487	412	783	5400620	98.49002
488	458	775	5401395	98.50415
489	111	763	5402158	98.51807
490	275	763	5402921	98.53198
491	324	763	5403684	98.5459
492	873	763	5404447	98.55981
493	952	763	5405210	98.57373
494	374	760.97	5405971	98.58761
495	313	742	5406713	98.60114
496	361	742	5407455	98.61467
497	443	742	5408197	98.6282
498	184	736	5408933	98.64162
499	231	730	5409663	98.65494
500	280	718	5410381	98.66803
501	615	704	5411085	98.68087
502	568	700	5411785	98.69363
503	276	674	5412459	98.70593
504	325	674	5413133	98.71822
505	423	674	5413807	98.73051
506	419	667	5414474	98.74267
507	8	654	5415128	98.7546
508	9	639	5415767	98.76625
509	861	636	5416403	98.77785
510	16	634.803	5417038	98.78943
511	25	633.078	5417671	98.80097
512	311	627	5418298	98.81241
513	359	627	5418925	98.82384
514	403	627	5419552	98.83528
515	220	625	5420177	98.84668
516	221	625	5420802	98.85807
517	222	625	5421427	98.86947

Appendix 15

Table 15: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
518	268	625	5422052	98.88087
519	317	625	5422677	98.89227
520	75	618.64	5423296	98.90355
521	11	617	5423913	98.9148
522	203	617	5424530	98.92605
523	293	617	5425147	98.93731
524	343	617	5425764	98.94856
525	387	617	5426381	98.95981
526	19	606.225	5426987	98.97087
527	773	604	5427591	98.98188
528	329	600	5428191	98.99282
529	370	600	5428791	99.00376
530	298	598	5429389	99.01467
531	347	598	5429987	99.02558
532	390	598	5430585	99.03648
533	23	580.113	5431165	99.04706
534	803	579	5431744	99.05762
535	112	574	5432318	99.06809
536	535	574	5432892	99.07856
537	536	574	5433466	99.08902
538	572	568	5434034	99.09938
539	41	567.555	5434602	99.10973
540	574	566	5435168	99.12005
541	582	566	5435734	99.13038
542	685	552.93	5436287	99.14046
543	409	547	5436834	99.15044
544	856	542	5437376	99.16032
545	49	538.273	5437914	99.17014
546	376	527.712	5438442	99.17976
547	143	523	5438965	99.1893
548	144	523	5439488	99.19884
549	371	506.781	5439994	99.20808
550	887	490	5440484	99.21701
551	963	490	5440974	99.22595
552	207	466	5441440	99.23445
553	363	466	5441906	99.24295
554	366	466	5442372	99.25145

Appendix 16

Table 16: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
555	399	466	5442838	99.25994
556	531	461	5443299	99.26835
557	1108	450.375	5443750	99.27656
558	1109	450.375	5444200	99.28478
559	768	434	5444634	99.29269
560	406	431	5445065	99.30055
561	15	429.007	5445494	99.30838
562	592	428	5445922	99.31618
563	595	428	5446350	99.32399
564	267	410	5446760	99.33146
565	316	410	5447170	99.33894
566	422	410	5447580	99.34642
567	181	408	5447988	99.35386
568	433	408	5448396	99.3613
569	522	408	5448804	99.36874
570	532	408	5449212	99.37618
571	33	394.723	5449607	99.38338
572	60	390.248	5449997	99.3905
573	37	374.696	5450372	99.39733
574	297	372	5450744	99.40411
575	346	372	5451116	99.4109
576	707	358.632	5451474	99.41744
577	870	353	5451827	99.42388
578	950	353	5452180	99.43031
579	936	336	5452516	99.43644
580	1005	336	5452852	99.44257
581	799	334	5453186	99.44866
582	304	329	5453515	99.45466
583	352	329	5453844	99.46066
584	859	325.6824	5454170	99.4666
585	306	323	5454493	99.47249
586	354	323	5454816	99.47838
587	617	323	5455139	99.48427
588	618	323	5455462	99.49016
589	699	319.752	5455782	99.49599
590	179	318	5456100	99.50179
591	180	318	5456418	99.50759

Appendix 17

Table 17: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
592	312	318	5456736	99.51339
593	360	318	5457054	99.51919
594	427	318	5457372	99.52499
595	14	308.142	5457680	99.53061
596	185	307	5457987	99.53621
597	533	307	5458294	99.54181
598	534	307	5458601	99.5474
599	92	299	5458900	99.55286
600	58	275.31	5459175	99.55788
601	662	272.808	5459448	99.56285
602	183	268	5459716	99.56774
603	287	268	5459984	99.57263
604	336	268	5460252	99.57751
605	577	248	5460500	99.58204
606	578	248	5460748	99.58656
607	869	247	5460995	99.59106
608	949	247	5461242	99.59557
609	84	241.532	5461484	99.59997
610	528	240	5461724	99.60435
611	735	240	5461964	99.60873
612	941	236	5462200	99.61303
613	1011	236	5462436	99.61734
614	524	225.75	5462661	99.62145
615	20	223.464	5462885	99.62553
616	123	216	5463101	99.62947
617	151	216	5463317	99.63341
618	560	216	5463533	99.63735
619	561	216	5463749	99.64128
620	119	212	5463961	99.64515
621	585	204	5464165	99.64887
622	586	204	5464369	99.65259
623	94	195	5464564	99.65615
624	201	195	5464759	99.6597
625	31	191.748	5464951	99.6632
626	757	176	5465127	99.66641
627	891	176	5465303	99.66962
628	965	176	5465479	99.67283

Appendix 18

Table 18: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
629	34	174.189	5465653	99.67601
630	649	165	5465818	99.67902
631	525	163.5817	5465981	99.682
632	774	160	5466141	99.68492
633	900	160	5466301	99.68783
634	973	160	5466461	99.69075
635	1039	160	5466621	99.69367
636	587	157	5466778	99.69653
637	601	157	5466935	99.6994
638	639	157	5467092	99.70226
639	642	157	5467249	99.70512
640	82	154.83	5467404	99.70795
641	701	153.409	5467558	99.71074
642	1099	150	5467708	99.71348
643	576	147	5467855	99.71616
644	643	147	5468002	99.71884
645	644	147	5468149	99.72152
646	562	146.7442	5468295	99.7242
647	916	145	5468440	99.72684
648	987	145	5468585	99.72949
649	575	144	5468729	99.73211
650	579	144	5468873	99.73474
651	588	144	5469017	99.73736
652	589	144	5469161	99.73999
653	648	144	5469305	99.74262
654	274	139	5469444	99.74515
655	323	139	5469583	99.74769
656	429	139	5469722	99.75022
657	645	139	5469861	99.75276
658	27	138.937	5470000	99.75529
659	928	138	5470138	99.75781
660	998	138	5470276	99.76032
661	21	133.53	5470410	99.76276
662	262	132	5470542	99.76517
663	35	129.642	5470671	99.76753
664	672	122.634	5470794	99.76977
665	526	120.7782	5470915	99.77197

Appendix 19

Table 19: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
666	24	119.805	5471035	99.77415
667	330	118	5471153	99.77631
668	12	113	5471266	99.77837
669	152	109	5471375	99.78036
670	580	108	5471483	99.78233
671	581	108	5471591	99.7843
672	736	107	5471698	99.78625
673	854	107	5471805	99.7882
674	567	105.25	5471910	99.79012
675	530	102.8292	5472013	99.792
676	679	100.351	5472113	99.79383
677	5	99	5472212	99.79563
678	177	99	5472311	99.79744
679	593	99	5472410	99.79925
680	596	99	5472509	99.80105
681	772	93	5472602	99.80275
682	29	91.148	5472694	99.80441
683	600	90	5472784	99.80605
684	6	88	5472872	99.80766
685	192	88	5472960	99.80926
686	194	88	5473048	99.81086
687	571	88	5473136	99.81247
688	594	88	5473224	99.81407
689	597	88	5473312	99.81568
690	598	88	5473400	99.81728
691	599	88	5473488	99.81889
692	608	88	5473576	99.82049
693	609	88	5473664	99.8221
694	7	87	5473751	99.82369
695	90	87	5473838	99.82527
696	199	87	5473925	99.82686
697	200	5	5473930	99.82695
698	205	87	5474017	99.82854
699	590	87	5474104	99.83012
700	591	87	5474191	99.83171
701	604	87	5474278	99.8333
702	605	87	5474365	99.83488

Appendix 20

Table 20: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
703	606	87	5474452	99.83647
704	607	87	5474539	99.83806
705	86	83.125	5474622	99.83957
706	216	82	5474704	99.84107
707	602	82	5474786	99.84256
708	603	82	5474868	99.84406
709	80	76.832	5474945	99.84546
710	673	76.481	5475021	99.84685
711	727	73	5475094	99.84819
712	264	72	5475166	99.8495
713	28	66.555	5475233	99.85071
714	17	56.58	5475289	99.85174
715	81	56.15	5475345	99.85277
716	251	56	5475401	99.85379
717	527	54.24512	5475456	99.85478
718	30	53.984	5475510	99.85576
719	85	51.18	5475561	99.8567
720	215	49	5475610	99.85759
721	217	49	5475659	99.85848
722	573	49	5475708	99.85938
723	734	48	5475756	99.86025
724	740	48	5475804	99.86113
725	749	48	5475852	99.862
726	880	48	5475900	99.86288
727	959	48	5475948	99.86375
728	1032	48	5475996	99.86463
729	224	45	5476041	99.86545
730	228	45	5476086	99.86627
731	583	45	5476131	99.86709
732	584	45	5476176	99.86791
733	659	39	5476215	99.86862
734	790	39	5476254	99.86933
735	1150	160	5476414	99.87225
736	1151	6063	5482477	99.98282
737	1154	39	5482516	99.98353
738	1155	39	5482555	99.98424
739	1173	39	5482594	99.98496

Appendix 21

Table 21: ABC Analysis (continued)

S/N	ITEMS	DEMAND	CUMULATIVE DEMAND	CUMULATIVE %
740	1174	39	5482633	99.98567
741	654	38	5482671	99.98636
742	731	37	5482708	99.98703
743	784	37	5482745	99.98771
744	1169	37	5482782	99.98838
745	1170	37	5482819	99.98906
746	729	36	5482855	99.98972
747	1152	36	5482891	99.99037
748	1153	36	5482927	99.99103
749	634	35	5482962	99.99167
750	635	35	5482997	99.99231
751	720	35	5483032	99.99294
752	632	33	5483065	99.99355
753	633	33	5483098	99.99415
754	810	33	5483131	99.99475
755	640	32	5483163	99.99533
756	641	32	5483195	99.99592
757	630	29	5483224	99.99644
758	631	29	5483253	99.99697
759	558	22	5483275	99.99738
760	914	20	5483295	99.99774
761	985	20	5483315	99.9981
762	661	17.28	5483332	99.99842
763	265	16	5483348	99.99871
764	721	9	5483357	99.99888
765	793	9	5483366	99.99904
766	805	5	5483371	99.99913
767	807	5	5483376	99.99922
768	835	5	5483381	99.99931
769	837	5	5483386	99.9994
770	841	5	5483391	99.9995
771	843	5	5483396	99.99959
772	1160	5	5483401	99.99968
773	1161	5	5483406	99.99977
774	1164	5	5483411	99.99986
775	237	4.656	5483416	99.99995
776	830	3	5483419	100
777		5483419		

Appendix 22

Forecasting methods showing actual demand behavior for Item 88

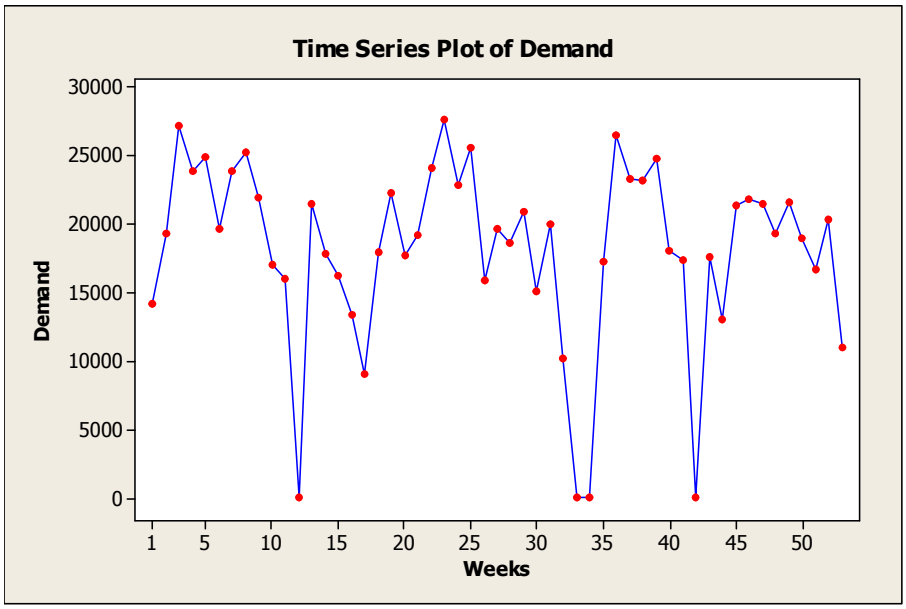

Figure 6.1 Time Series Plot showing actual demand

Appendix 23

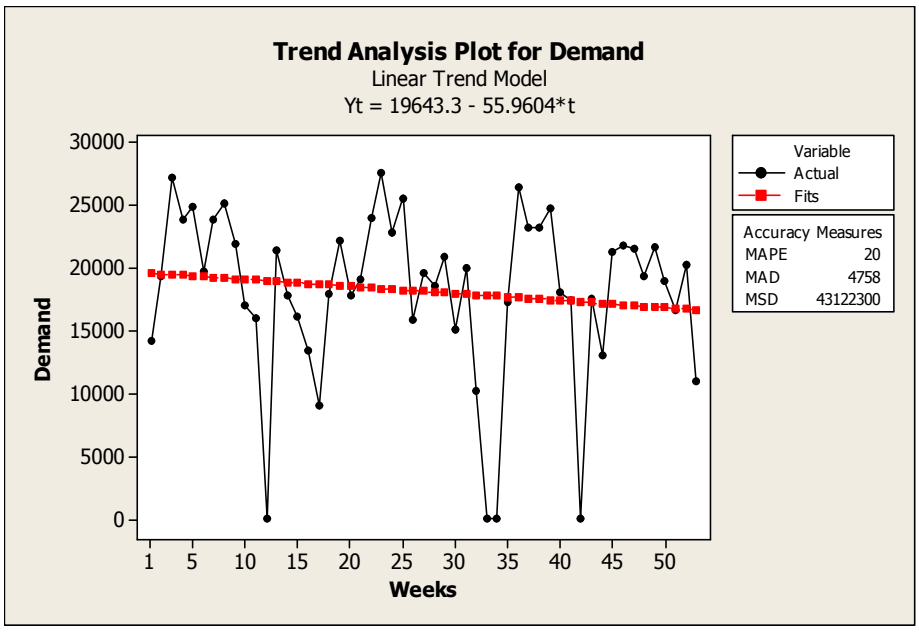

Figure 6.2 Trend Analysis Plot showing actual demand

Appendix 24

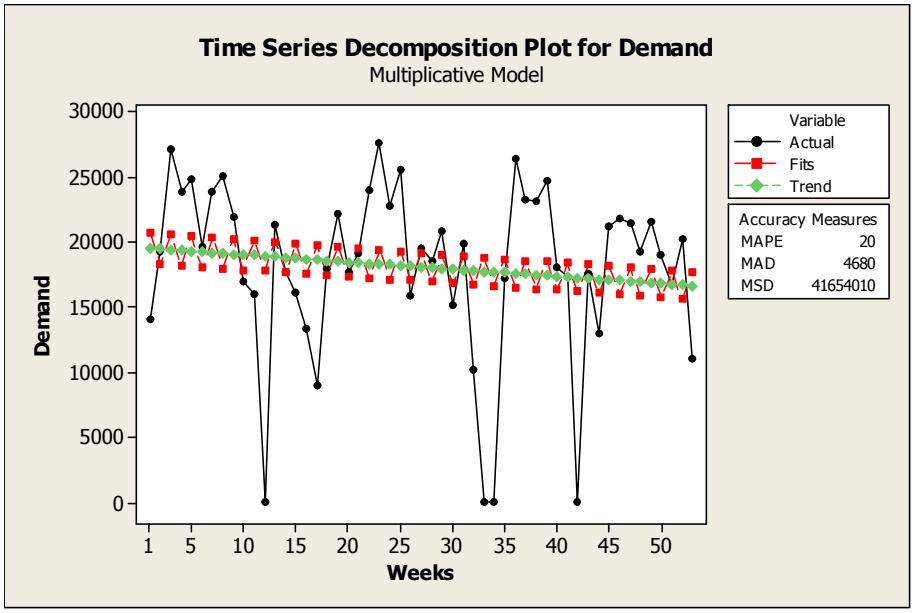

Figure 6.3 Time Series Decomposition with seasonal length of 2 showing actual demand

Appendix 25

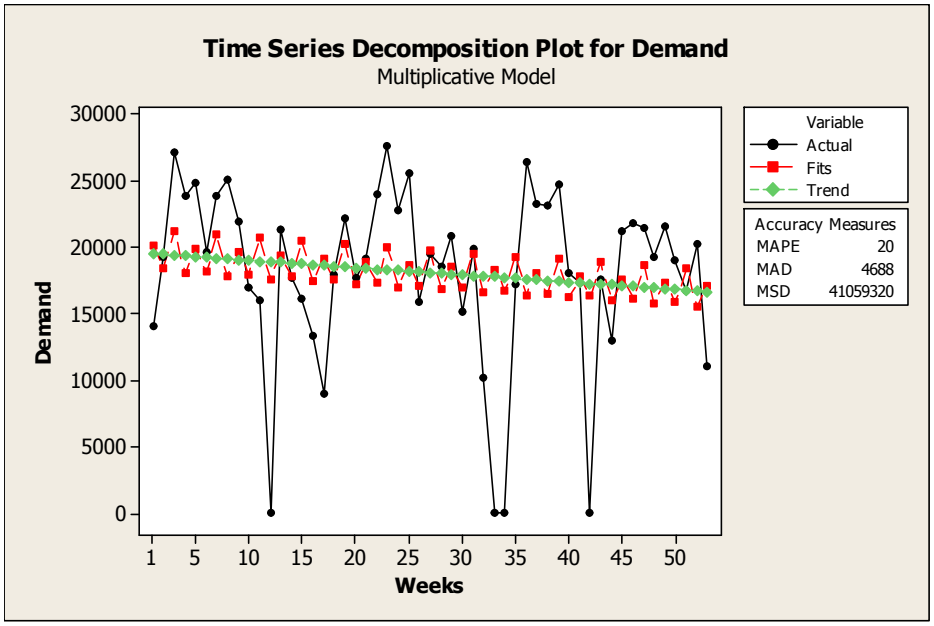

Figure 6.4 Time Series Decomposition with seasonal length of 4 showing actual demand

Appendix 26

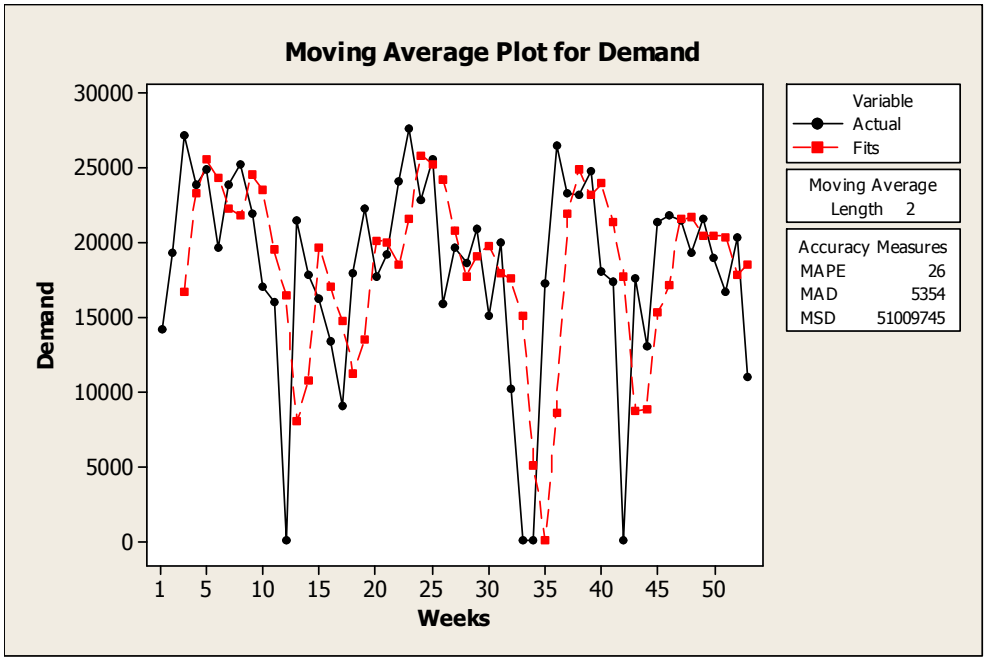

Figure 6.5 Moving Average with seasonal length 2 showing actual demand

Appendix 27

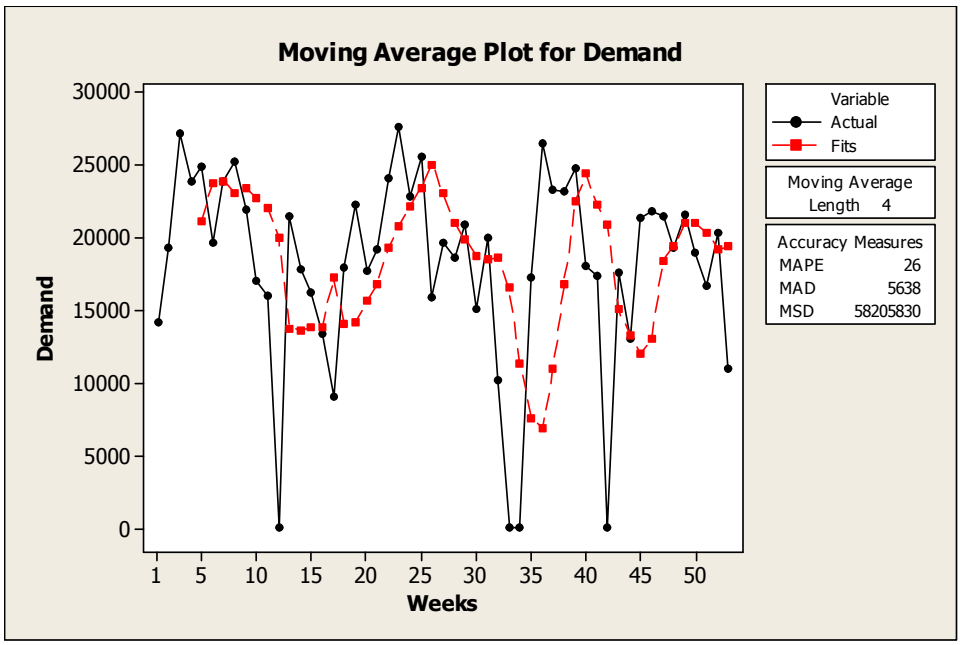

Figure 6.6 Moving Average with seasonal length 4 showing actual demand

Appendix 28

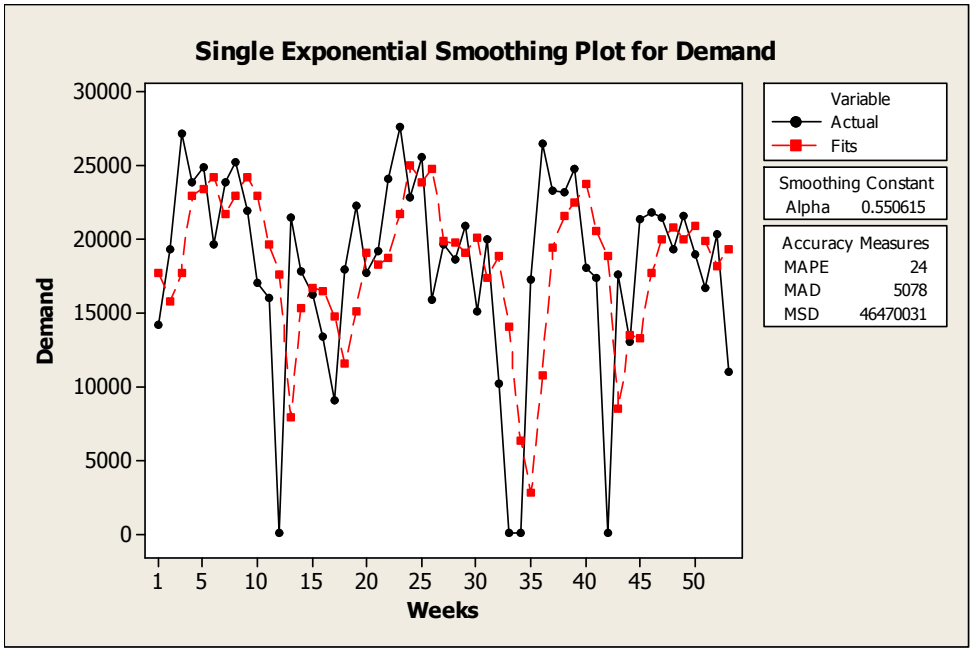

Figure 6.7 Single Exponential Smoothing showing actual demand

Appendix 29

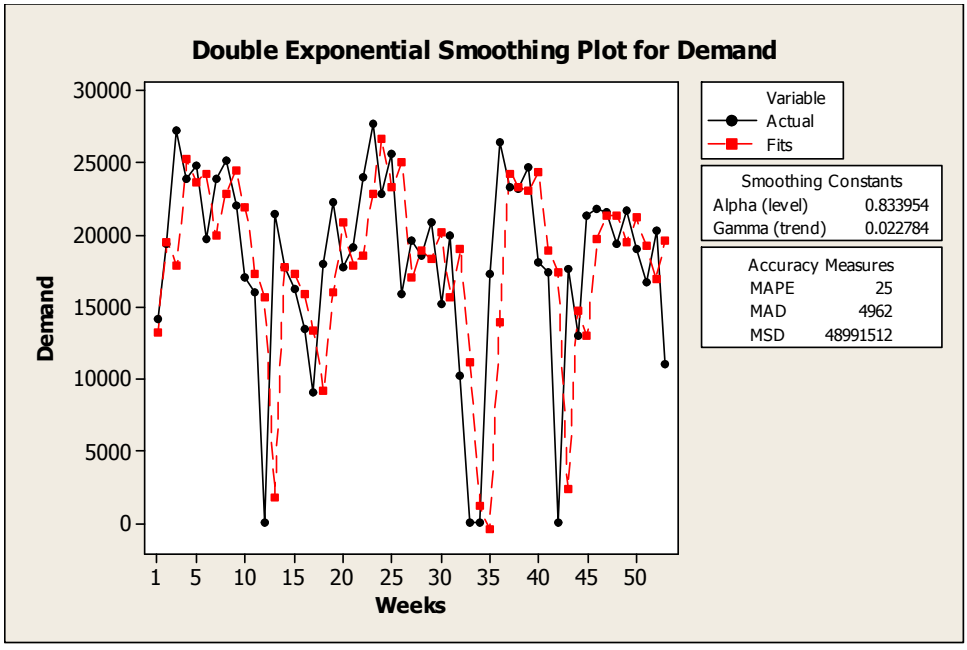

Figure 6.8 Double Exponential Smoothing showing actual demand

Appendix 30

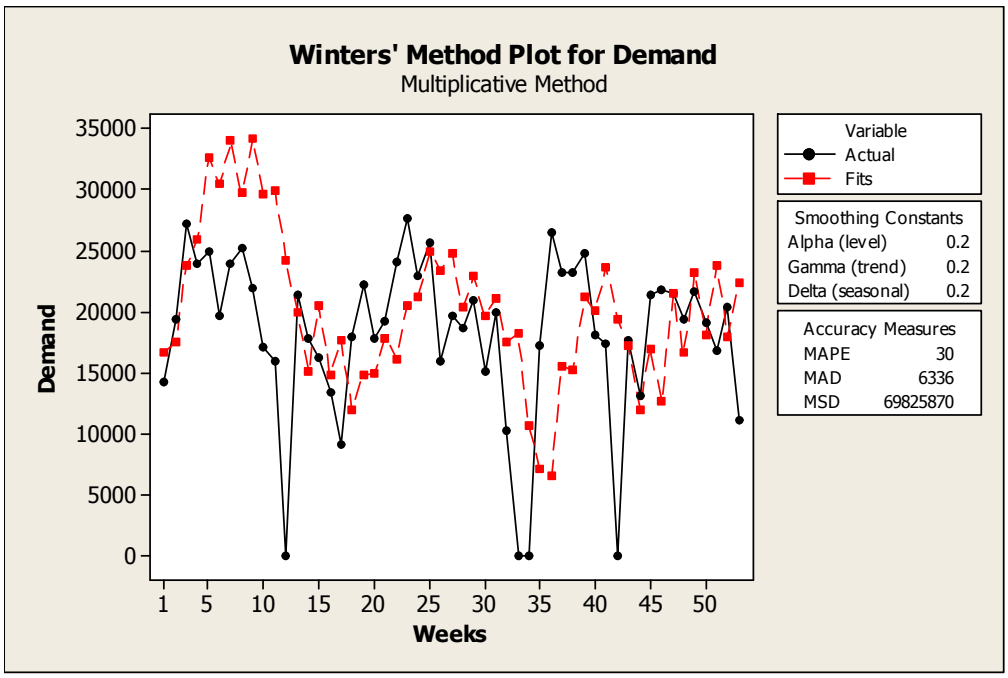

Figure 6.9 Winters' Method with seasonal length of 2 showing actual demand

Appendix 31

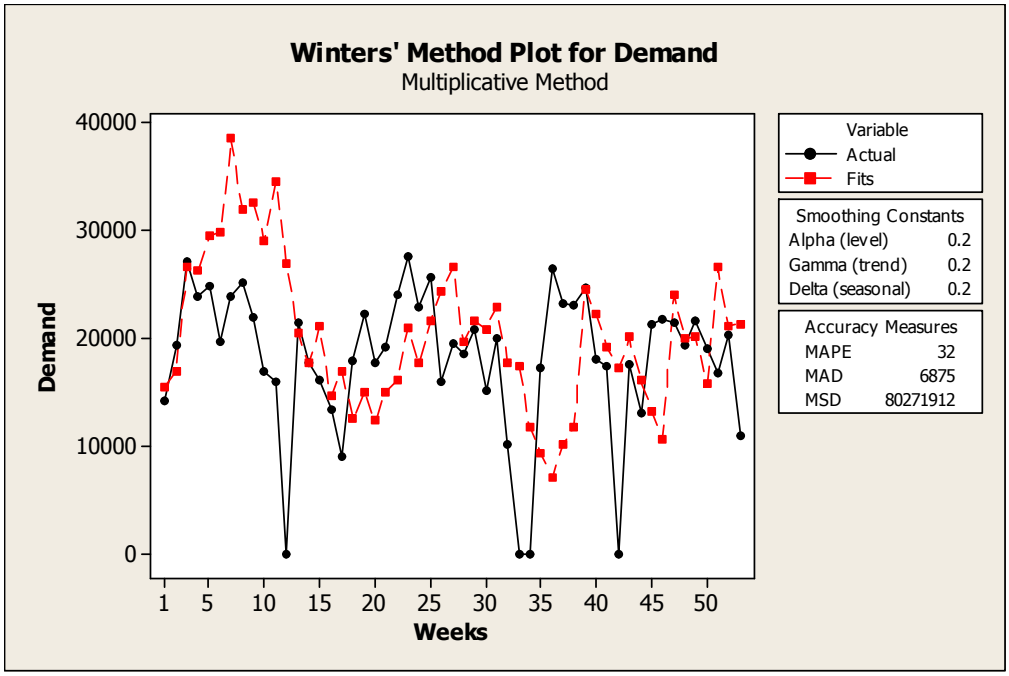

Figure 6.10 Winters' Method with seasonal length of 4 showing actual demand

Appendix 32

Forecasting method showing forecasted demand behavior

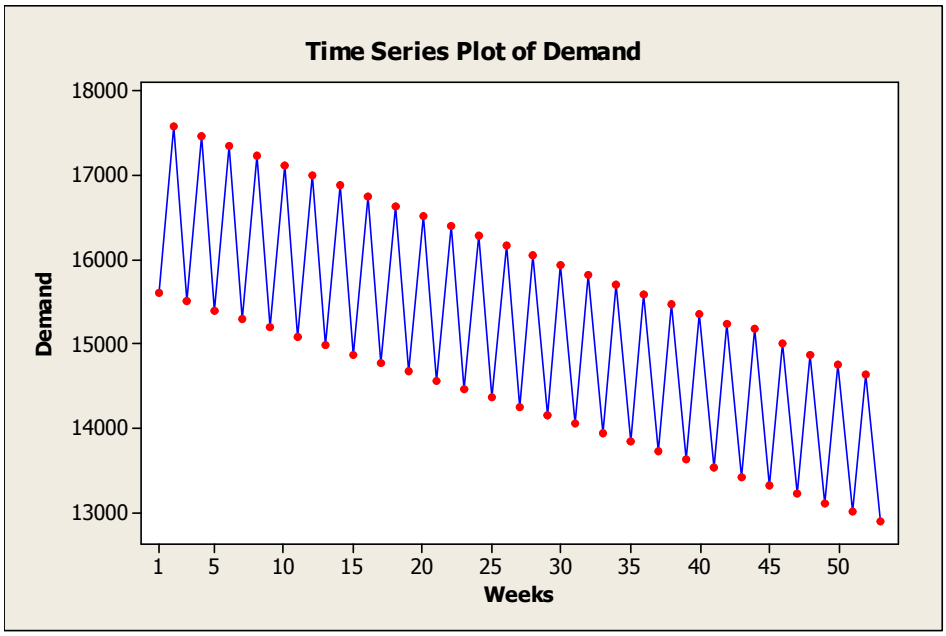

Figure 6.11 Time Series Plot showing 52 weeks forecasted demand

Appendix 33

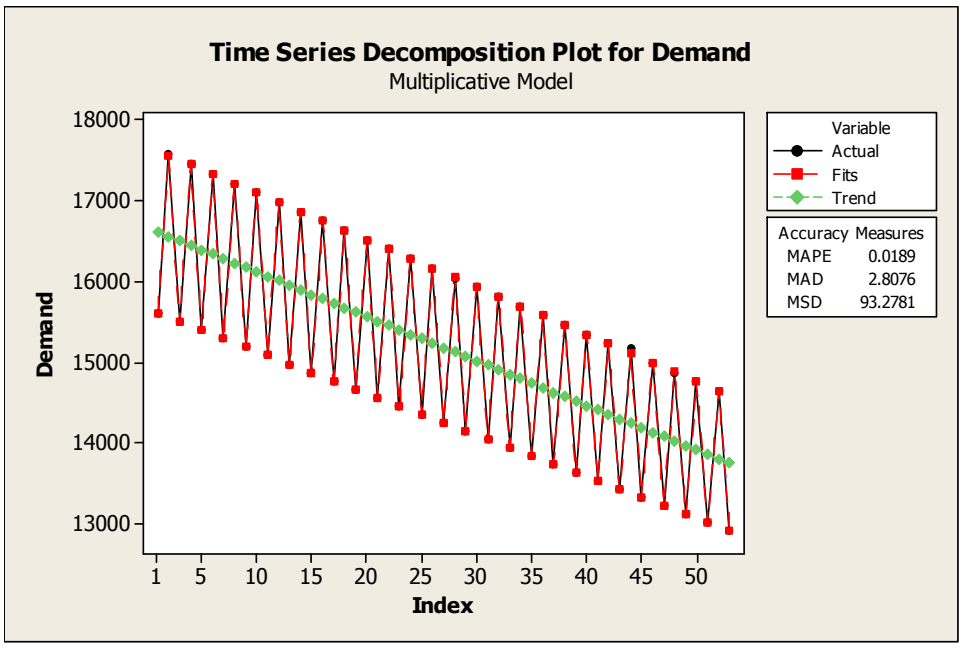

Figure 6.12 Time Series Decomposition with seasonal length 2 showing 52 weeks forecasted demand

Appendix 34

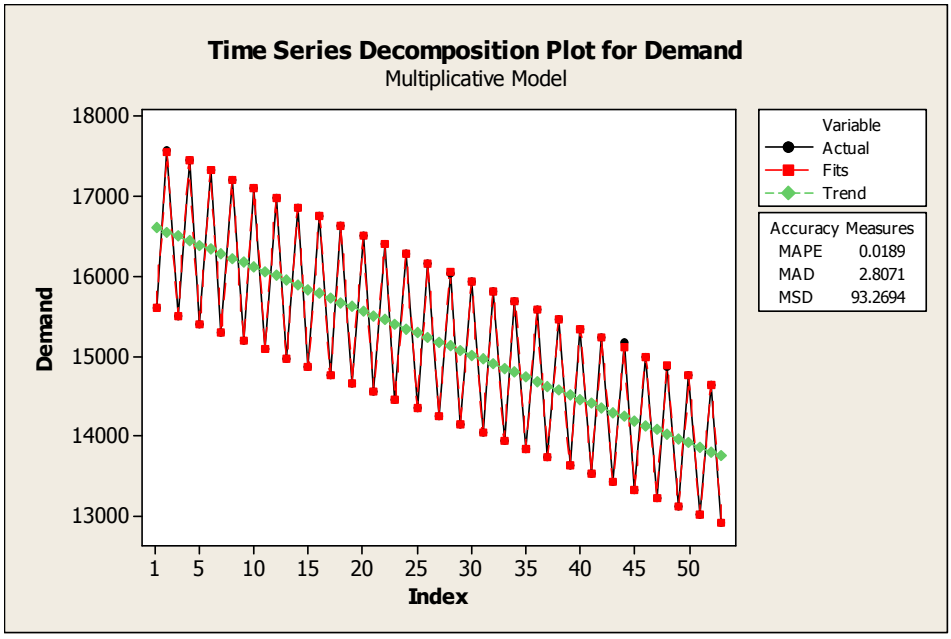

Figure 6.13 Time Series Decomposition with seasonal length 4 showing forecasted demand

Appendix 35

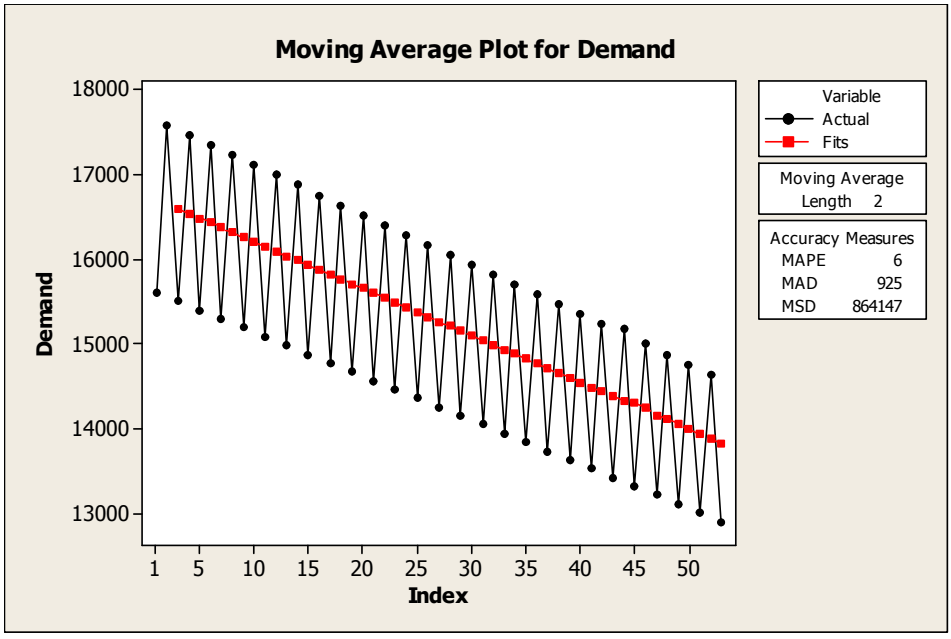

Figure 6.14 Moving Average with seasonal length 2 showing forecasted demand

Appendix 36

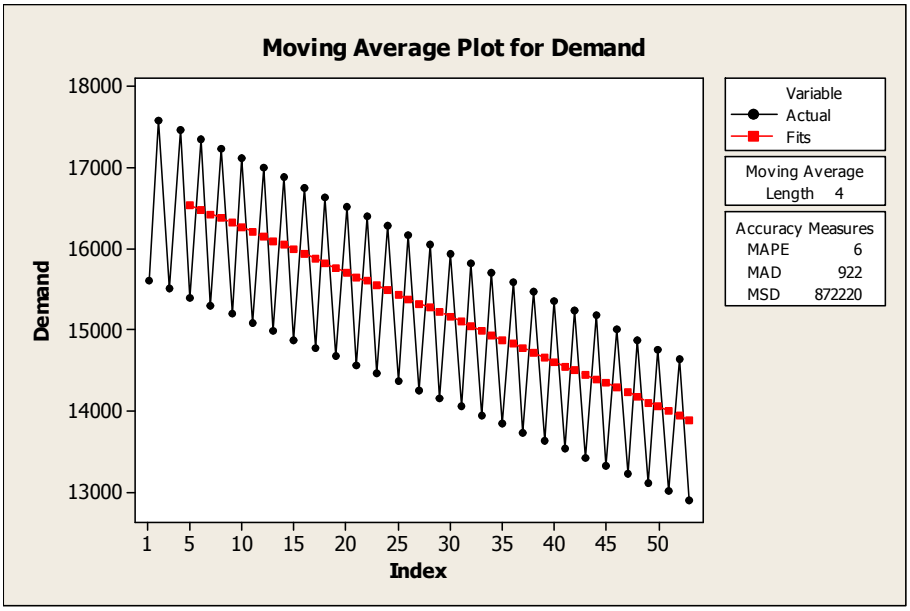

Figure 6.15 Moving Average with seasonal length of 4 showing forecasted demand

Appendix 37

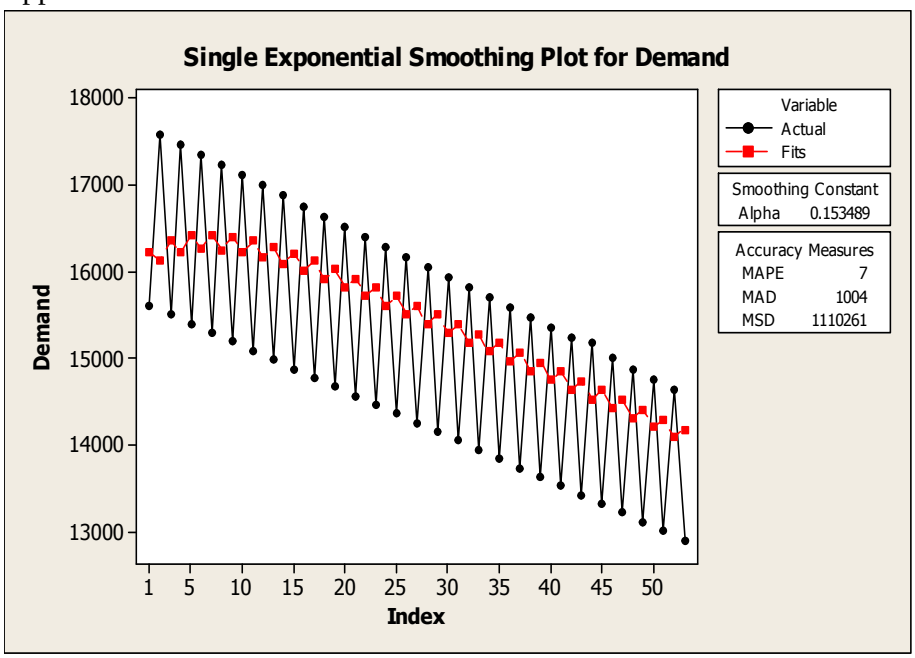

Figure 6.16 Single Exponential Smoothing showing forecasted demand

Appendix 38

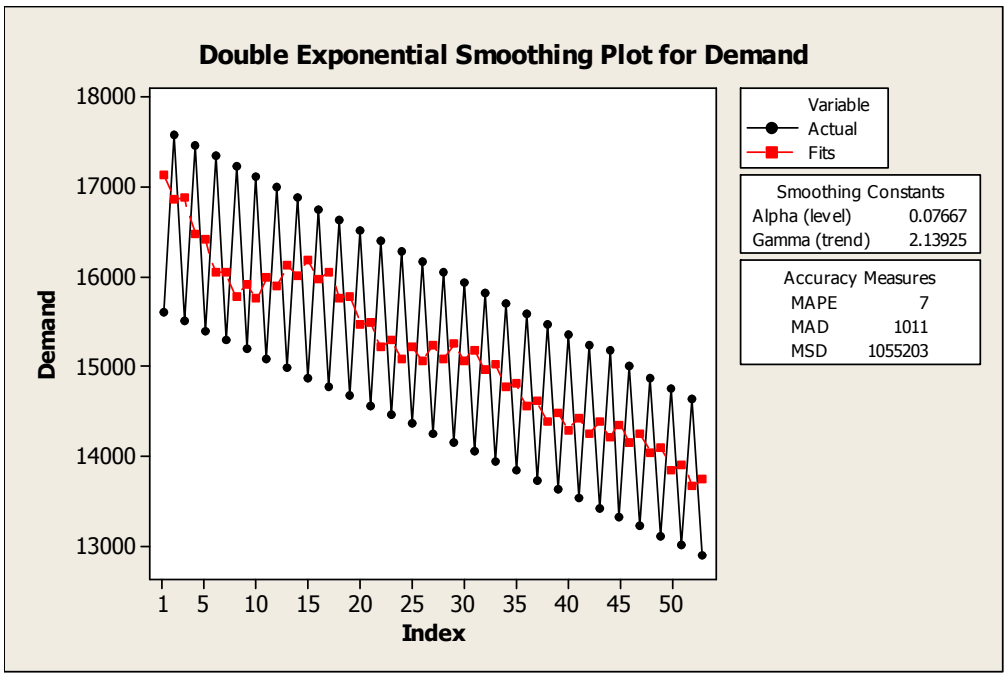

Figure 6.17 Double Exponential Smoothing showing 52 weeks forecasted demand

Appendix 39

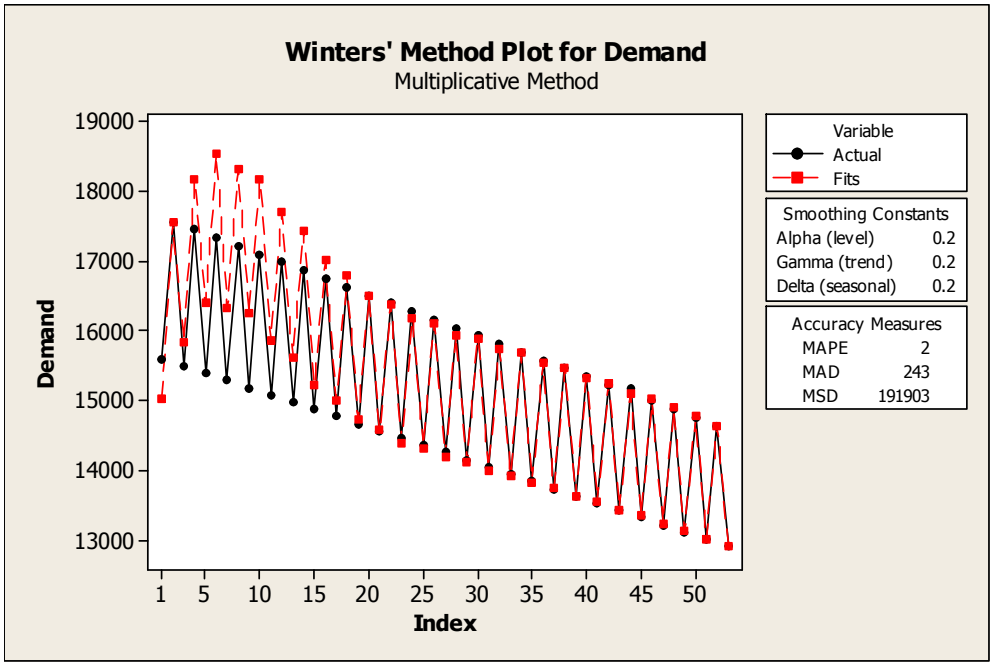

Figure 6.18 Winters' Method with seasonal length of 2 showing 52 weeks forecasted demand

Appendix 40

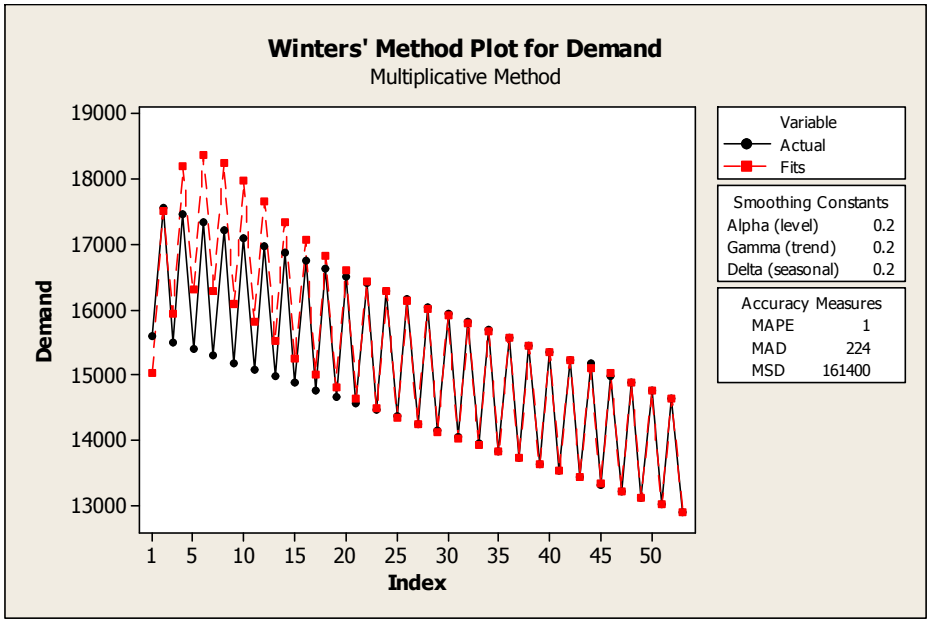

Figure 6.19 Winters' Method with seasonal length of 4 showing 52 weeks forecasted demand

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