Demand Forecasting for Strategic Resource Planning

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Abstract

Demand forecasting is to forecast the future demand so that manager can easily control the production. Demand is defined as a need (Balbo, Gabriel. 2005). From need we will know how much to supply. Therefore, in this study the expected result is that demand forecasting can be effectively used by the manager to make decision in strategic resource planning. This research study objective is to determine how the implementation of demand forecasting into strategic resource allocation decision can be done and to analyze the issues and develop the new model that will affect the results of demand forecasting and strategic resource planning. To prove this study, the data collection from the firm is needed. The study will be proven from the simulation of the demand forecasting with the collected data from the firm in 4-5 years in order find the best model. The demand data of steel is provided by the Joon Hee MICRON Sdn. Bhd. Nevertheless, Demand Forecasting and Strategic Resource planning are having positive relationship. The hypothesis is accepted. The objectives are successfully achieved and the new model is created. Decisions are made all the time, although sometimes the decision comes unconsciously (Fraga & Anema, 2009). Demand forecasting will be the key to effective decision making process for strategic resource planning.

Keywords
Demand Forecasting, Strategic resource planning, model, simulation, decision making

1.0 INTRODUCTION

1.1 Definition

As its name implies, demand forecasting is basically used to forecast the future demands. It is also a fundamental managerial task. Demand forecasting is a process whereby forecasting leader works with internal and external stake holders to estimate which product and how much of each need to be produced to meet customer requirement (David, R. M., 2009). Without the link between forecast and resource allocation, it would be very difficult to acquire resource to make on-time deliveries to customers. Demand forecasting form the basis of the strategic resource planning because the raw materials, packing, catalogue, semi-manufacturing, machine, manpower and investment requirement will be determined according to the planning. Nevertheless, there exist several forecasting methods which can provide different results which all have their own advantages, disadvantages and feasibilities (Bonde, H. & Hvolby, H., 2007). When managers understand about the limitations of the forecast methods, they will know which strategic resource allocation procedures that is most helpful to reduce the forecast errors. These are the evolution of forecasting methods since early 1950s. In conclusion, demand forecasting will be a key to managerial tools to strategic resource allocation decision (John, G. W. & Rhonda, R. L., 2002).

1.2 Research Background

Forecasting is a type of activity in the oldest management. Forecasting means estimating a future event or condition which is outside an organization's control and provides a basis for managerial planning (Annastiina. K., 2010). Normally, companies do not know about their future demand so they use the demand forecasting to assist them to make decision in production planning, sourcing and inventory management both in long and short term productivity. Accurate forecasting is important for yield management, helping managers plan strategies to match capacity with demand in order to achieve high yield levels. (William Stevenson, 2011). As a result, many firms have reformed their demand forecasting process in the supply chain so as to achieve a high degree of forecasting accuracy and connectivity among operational plans.

1.3 Problem Statement

Demand forecasting is needed whenever there are products manufacturing. Sales and Operation Planning group uses demand forecasting to do the decision making for the strategic resource planning (William Stevenson, 2011). Behaviour changing of the customers during the seasonal period in sales will cause the demand forecasting to be unstable. The behaviour changing of customers depends on the environment, economic, health and so forth, therefore it is unpredictable (Stefan, G., 2011). Besides that, time period makes decision making very difficult due to the constant changing variables of short, medium and long period. Short-term forecasting deals with hourly, daily, weekly and monthly forecasts. Long-term forecasting usually covers long time horizon such as one year, ten years and sometimes up to thirty years. Furthermore, long-term forecasting is characterized by large uncertainties caused by distant future, which makes long-term forecasting very challenging Selection of a suitable demand forecasting model is therefore very difficult (Brockwell, P. J., 2002).

Furthermore, the impact of forecast errors on strategic decision will be an important issue which makes costing become larger in production planning. Apart from cost, schedule instability and system service level are greatly affected as well. Forecast errors make decision making difficult (William Stevenson, 2011). Moreover, the strategic policies of the organization did not adopt to enable their manager to react more effectively to forecast errors. A change of the strategic policies should be made for better decision making (John, G. W. & Rhonda, R. L., 2002).

This study consists of two main objectives which are:

a) To determine how the implementation of demand forecasting into strategic resource allocation decision can be done.
b) To analyse the issues and develop a new model that will affect the results of demand forecasting and strategic resource planning.

2.0 LITERATURE REVIEW

2.1 Introduction

The aim of literature reading is to review the previous researches and the theories related to this research. Prevent the mistake that are doing of the similar research, and more deeply reading to define the way to do the research.
Forecasting is a condition and alternative statement related to the possible and probable that what, when and why to the future. A need of forecast is arisen to the information on the possible, probable, and preferred implication of the change in the future. Forecast does not predict what will happen in the future but it anticipates the possible threats to, and opportunities for development (Gál, F., & Frič, P., 1987). The data-based forecasting can be classified into regression analysis, decomposition, smoothing and autoregressive moving average methods. A new forecasting procedure believes that to develop as the need for accurate forecasts accelerates. In forecasting process, an organization must pay attention to the needs to coordination objectives, methods, assessment, and interpretation (John, E. H. & Dean, W., 2014). Forecasts can be made with a reference for a specific time horizon. It can be in short or longer period. For example short-term period is an hour, day, week, or month; long-term period is the next six months, the next year, the next five year or the life cycle of a product or service. Mostly, short-term forecasts are use in ongoing operation and long-term forecast is more important for the strategic planning tool. Forecasts can affect the decisions and activities throughout an organization, for example in operation, the schedules, capacity planning, work assignments and workloads, inventory planning, make-or-buy decisions, outsourcing and project management. (Stevenson, W. 2011) Demand concept is developed by Jacques Lacan, which is linking the need and

desire to the demand concept. The function of demand is to drive the subject demand and other coincide demand (Balbo, Gabriel. 2005). Demand show "what the customers want, and when they want it," in operation term, it becomes "what are the materials used, and when are the materials needed." (Gilliland, 2010)

Demand forecasting is using the demand to analyse the future demand. In business forecasting, demand is a thing that is essential (Gilliland, 2010). Demand forecast is coordination for the suppliers and operation to wide range of the inventory management, shipping, distribution, reclamation, repair and maintenance. Demand forecast is an analysis and norm process of the previous data information to make a possible forecast of future plan. Processor demand and indication of formal demand is a multi-stage process of demand forecasting. To improve the processor demand of production, the evaluation and determining of the interior and exterior must be taken. The decision will be made by the decision makers who will select the most appropriate forecast techniques for the nature of the problem. The aim of the demand planning is to accelerate the flow of production, for example the flow of raw materials, from the material to the product, and the finish goods to the customers. (Kocaoglu, Acar, & Yilmaz, 2014). Forecasting error can be defined as the absolute difference between the forecast and the actual sales. The impact of forecast error on strategic decision has been considered an important issue since the earliest writings on production planning and control (Holt, C. C., et al., 1955).

2.3 Strategic Resource Planning

Resource planning of business includes plant expansion, capital equipment purchase, and anything requiring a long lead time to purchase (Kerkkänen, 2010). A good resource planning can avoid the unnecessary cost and order form the material. The most important part of strategic resource planning is do the right decision (John & Rhonda, 2002). For the definition of "supply chain", La Londe and Masters proposed that a supply chain is a set of firm that pass materials forward between demander and supplier (Londe, L. & Master, 1994). Christopher also defined supply chain as a type of network of organization which is in different process and activities that produce value in the form of products and service delivered to the ultimate customer through the upstream and downstream (Mentzer et. al., 2001)

Decision making process is an interesting subject. As an organization decision maker, manager usually prefer a choice which would lead to good performance. Decisions are made all the time, although sometimes the decision comes unconsciously. Decision was a subject that can be relevant in many business area, situation, although to optimal the new policies concerning forecasting, cost and price management (Fraga & Anema, 2009)

The study of the inventory control can be categorised into different time buckets for demand recording, including individual orders and different time buckets (week, monthly, bi-monthly and quarterly) (Rego & Mesquita, 2015). Raw material was a part of the manufacturing inventory. In Strategic Resource Planning, inventory control is an essential subject. Extrapolative forecasting methods are widely used in production and inventory decisions (Fildes & Beard, 1992).

3.0 Research Methodology

3.1 Introduction

The aim of this study is to help the manager get the decision making in a more systematic way by using the calculation of the demand forecasting. In this research, there will be a hypothesis as listed below.

H1: There is a positive relationship between Demand Forecasting and Strategic Resource Planning.
Figure below shows the conceptual framework of this study.

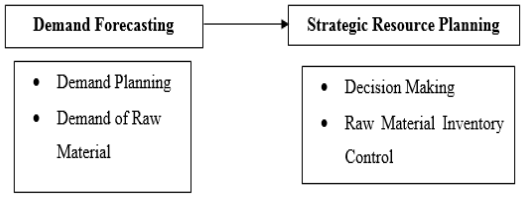

Figure 3.1, Conceptual Framework.

3.4 Forecasting Method

The following methods are taken from J. Holton Wilson. (Wilson, J. H., 2007)

a) Moving Averages

The simple statistical method of moving averages may mimic some data better than a complicated mathematical function.

The equation of the Moving Average,

$$\frac{X1+X2+X3+X4+X5+\cdots+Xn}{n} \qquad (3.1)$$

b) Exponential Smoothing

- *Simple Exponential Smoothing:* With exponential smoothing, the forecasts value at any time is a weighted average of all the available previous values.

The equation of the Simple Exponential Smoothing,

$$F_{t+1} = \propto X_t + (1-\propto)F_t \qquad (3.2)$$

Where:

F_{t+1}= Forecasting value for period t + 1

$\propto$ = Smoothing constant (0< $\propto$ < 1)

X_t = Actual value now (in period t)

F_t = Forecast (i.e., smoothed) value for period t

- *Holt-Winters' Exponential Smoothing:*

Holt's is calculated by two-parameter exponential smoothing method which is an extension of simple exponential smoothing; it adds a growth factor to the smoothing equation as a way of adjusting for the trend.

The equation of Holt's Exponential Smoothing,

$$F_{t+1} = \propto X_t + (1-\propto)(F_t + T_t) \qquad (3.3a)$$
$$F_{t+1} = \gamma(F_{t+1} - F_t) + (1-\gamma)T_t \qquad (3.3b)$$
$$H_{t+m} = F_{t+1} + mT_{t+1} \qquad (3.3c)$$

Where:

F_{t+1} = Smoothed value for period t + 1

$\propto$ = Smoothing constant for the level (0 < $\propto$ < 1)

X_t = Actual value now (in period t)

F_t = Forecast (i.e., smoothed) value for time period t

T_{t+1} = Trend estimate

γ = Smoothing constant for the trend estimate (0 < γ < 1)

m = Number of periods ahead to be forecast

H_{t+m}= Holt's forecast value for period t + m

Winters' exponential smoothing model is the second extension of the basic smoothing model; it is used for data that exhibit both trend and seasonality.

The Winters' Exponential Smoothing,

$$F_t = \frac{\propto X_t}{S_{t-p}} + (1-\propto)(F_{t-1} + T_{t-1}) \qquad (3.4a)$$
$$S_t = \beta X_t/F_t + (1-\beta)S_{t-p} \qquad (3.4b)$$
$$T_t = \gamma(F_t - F_{t-1}) + (1-\gamma)T_{t-1} \qquad (3.4c)$$
$$W_{t+m} = (F_t + mT_t)\, S_{t+m-p} \qquad (3.4d)$$

Where:

F_t = Smoothed value for period t

$\propto$ = Smoothing constant for the level (0 < $\propto$ < 1)

X_t = Actual value now (in period t)

F_{t-1} = Forecast (i.e., smoothed) value for time period t - 1

T_{t+1}= Trend estimate

S_t = Seasonality estimate

β = Smoothing constant for seasonality estimate (0 < β < 1)

γ = Smoothing constant for the trend estimate (0 < γ < 1)

m = Number of periods ahead to be forecast lead period
W_{t+m}= Winters' forecast value for m period into the future

Holt-Winters method will be just calculated in one equation to find whether the trend is Holt or Winter. Winter normally is same with Holt but just having the seasonality estimation.

- *Adaptive-Response-Rate Single Exponential Smoothing:* Adaptive-response smoothing does not use one single α value like the simple exponential smoothing model does.

The equation of ADRES,

$$F_{t+1} = \alpha_t X_t + (1 - \alpha_t) F_t \qquad (3.5)$$

Where:

$\alpha_t = \left| \frac{S_t}{A_t} \right|$

$S_t = \beta e_t + (1 - \beta) S_{t-1}$ (Smoothed error)

$A_t = \beta \left| e_t \right| + (1 - \beta) A_{t-1}$ (Absolute smoothed error)

$e_t = X_t - F_t$ (Error)

c) Regression

Bivariate regression analysis (also called simple linear least-squares regression) is a statistical tool that gives us the ability to estimate the mathematical relationship between a dependent variable (Y) and a single independent variable (χ).

The equation of Regression,

$$Y = f(X) \qquad (3.6a)$$
$$Y = \beta_0 + \beta_1 X + \varepsilon \qquad (3.6b)$$
$$\hat{Y} = b_0 + b_1 X \qquad (3.6c)$$

Where:

β_0 = the intercept of the regression line on the vertical axis

β_1 = the slope of the regression line

d) Multiple Regression

Multiple regression is a statistical procedure in which a dependent variable (Y) is modelled as a function of more than one independent variable (X1, X2, X3,…,Xn).

The equation of Multiple Regression,

$$Y = f(X_1, X_2, X_3, \dots, X_n) \qquad (3.7a)$$
$$= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_k X_k + \varepsilon$$
$$\sum \varepsilon^2 = \sum (Y - \hat{Y})^2 \qquad (3.7b)$$

e) Time-Series Decomposition

The information provided by time-series decomposition is consistent with the way managers tend to look at data and often helps them to get a better handle on data movements by providing concrete measurements for factors that are otherwise not quantified.

The equation of Time Series Decomposition,

$$Y = T \times S \times C \times I \qquad (3.8)$$

Where:

Y = the variable that is to be forecast
S = the seasonal adjustment factor
C = the cyclical adjustment factor
I = the irregular or random variation in the series

For quarterly data:

$$MA_t = \frac{Y_{t-2} + Y_{t-1} + Y_t + Y_{t+1}}{4} \qquad (3.9a)$$

For monthly data:

$$MA_t = \frac{Y_{t-6} + Y_{t-5} + \cdots + Y_t + Y_{t+1} + \cdots + Y_{t+5}}{12} \qquad (3.9b)$$

Centered Moving Average:

$$MA_t = \frac{MA_t + MA_{t+1}}{2} \qquad (3.9c)$$

f) ARIMA (Box-Jenkins) – Type Forecasting Models

The Box-Jenkins methodology of using ARIMA (Autoregressive Integrated Moving Average) models is a technically sophisticated way forecasting a variable by looking only at the past pattern of the time series.
The equation of ARIMA,

$$\text{ARIMA (p,d,q) (P,D,Q)}^s \qquad (3.10)$$

Where:
p = Level of autoregressions
d = Level of normal differencing
q = Level of seasonal differencing
P = Seasonal level of autoregressions
D = Level of seasonal differencing
Q = Seasonal level of moving averages
S = Period of seasonality (usually 4 for quarters, 12 for months, etc.)

3.5 `Evaluating Forecasts

In order to select the best model for a period, equations listed below are used to calculate the error.

Let,
A_t = Actual value in period *t*
F_t = Forecast value in period *t*
n = Number pf periods used in the calculation

a) The Mean Error,

$$ME = \frac{\sum (A_t - F_t)}{n}$$

b) The Mean Absolute Deviation,

$$MAD = \frac{\sum \left|(A_t - F_t)\right|}{n}$$

c) The Mean-Squared Error,

$$MSE = \frac{\sum (A_t - F_t)^2}{n}$$

d) The Root-Mean-Squared Error

$$RMSE = \sqrt{\frac{\sum (A_t - F_t)^2}{n}}$$

e) The Tracking Signal,

$$TS = \frac{\text{Accumulated Forecast Errors}}{\text{Mean Absolute Deviation}}$$

Normally to compare the forecast model the RMSE is commonly used due to its similarity to the basic statistical concept of a standard deviation (Wilson, J. H., 2007).

3.7 Data Analysis

The demand data will include the demand of raw material for 4 - 5 years (60 months) of company Joon Hee MICRON Sdn. Bhd. from the Klang, Selangor.

a) Risk Simulator Analysis

Risk Simulator is a Monte Carlo simulation, Forecasting and Optimization software. This software is written in Microsoft NETC# and functions together as an add-in in Microsoft Excel.

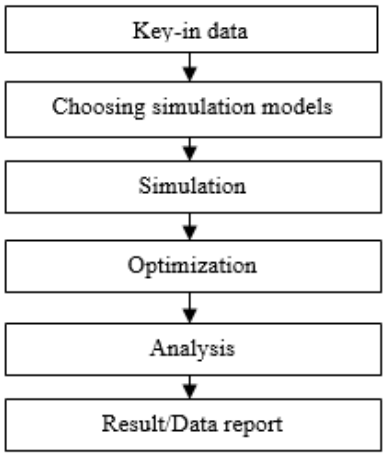

Figure 3.3, Risk Simulator process flow chart.

Figure 3.2 shows the flow chart of the Risk Simulation Process, basically consisting of 6 steps (Mun, J., 2012).

b) Forecast X Software

After calculation using existing models, a new model was developed using Forecast X Software to determine the new (p,d,q). Forecast X Software is a type of add-in software in Excel which are created by the John Galt Solution, Inc (Wilson, J. H., 2007).

4.0 RESEARCH RESULT

The demand data is provided by the company Joon Hee MICRON Sdn. Bhd. from the Klang, Selangor. The data is collected in 56 month which is from January 2011 until August 2015. The raw material used to forecast is the main material of the Joon Hee MICRON Sdn. Bhd. which is the steel.
**The Result of all the Method will be show out in the appendixes behind the Reference.*

4.1 Moving Average Method

Figure 4.1 shows the result of the forecasting using the Moving Average Method calculated in three- and five-quarter moving average. Choosing this because it is a better forecasting model which is useful to compute the root-mean-squared error (RMSE).

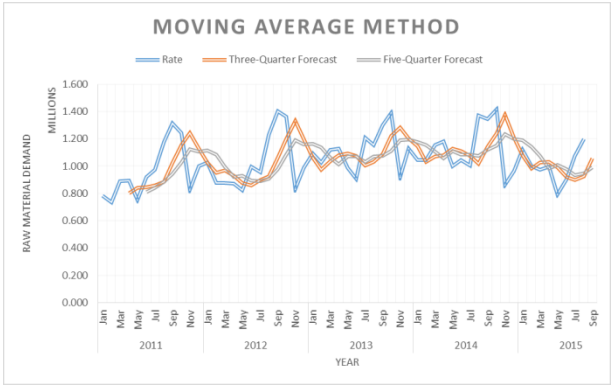

Figure 4.1, Moving Average Method.

From the result, the RMSE of 195, 219.12 for the three-quarter moving average is less than the 196, 097.63 calculated for the five-quarter case. Since better forecast is obtained using this method the best model is the three-quarter moving averages

4.2 Exponential Smoothing

4.2.1 Simple Exponential Smoothing

Figure 4.2 shows the result of the Simple Exponential Smoothing Method which calculates the smoothing value α=0.9 and α=0.1.

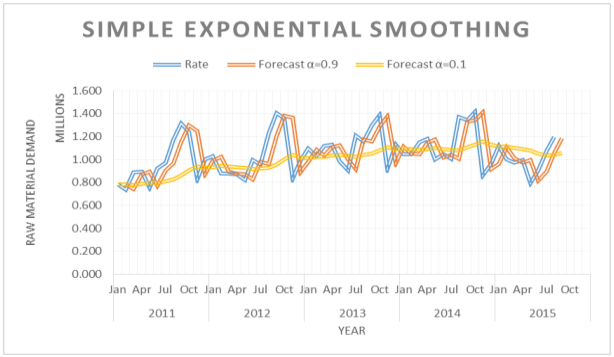

Figure 4.2, Simple Exponential Smoothing.

The value of the smoothing constant α must be between 0 and 1, the value cannot equal to 0 and 1. If the value close to 1 is chosen, recent values of the time series are weighted heavily relative to those of the distant past when the smoothed value are calculated. But if the value of α is chosen close to 0, then the value of the time series in the distant past are given weights comparable to those given the recent values.

Based on the result of this method, the RMSE of α=0.1 is 182, 438.56 which is lower than α=0.9 is 229, 912.41. The α=0.1 is the better forecast for this method.

4.2.2 Holt-Winters' Exponential Smoothing

The Holt-Winters Smoothing in this research are using the α=0.1601, β=0.0001 and γ=0.4281. Based on the result shown in Figure 4.3 the forecast is in the cycle.

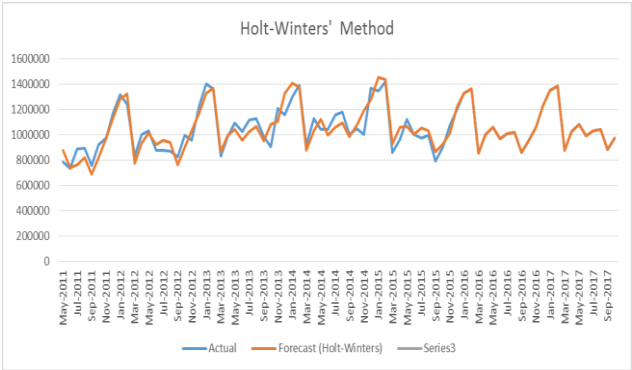

Figure 4.3, Holt-Winters' Method.

The RMSE of this Holt-Winter Smoothing is 77, 533.89. The Winter is used for calculation due to the trend of the demand of the steel.

4.2.3 Adaptive-Response-Rate Single Exponential Smoothing (ADRES)

ADRES does not use one single α value like simple exponential smoothing model does. The word adaptive in its name gives a clue to how rather adapt to the data. When that is a change in the basic pattern of the data, the α value adapts.

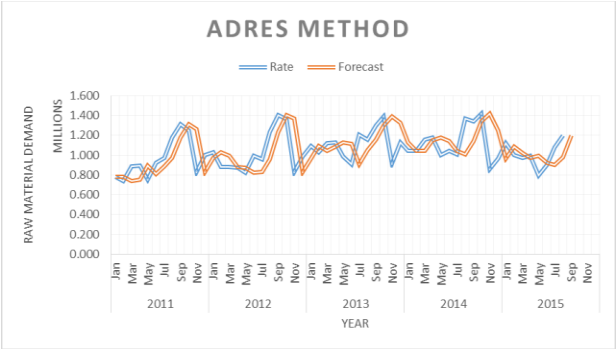

Figure 4.4, ADRES Method.

Figure 4.4 shows the result ADRES Method which is forecast in the smoothing factor β=0.2 and the RMSE 197, 098.15.

4.3 Regression

Regression Method also called Simple Linear Least-Square Regression is using the statistical tool to calculate the forecast. Based on the result in Figure 4.5, the forecast line is present in straight line.

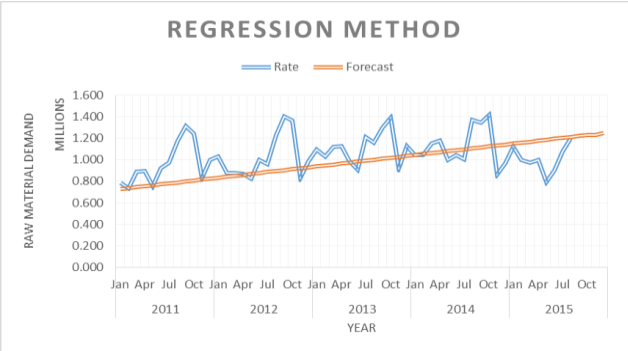

Figure 4.5, Regression Method.

The straight line is calculated by the formula y=8793.483x+718678.625. The RMSE of this method is 210, 542.70.

4.4 Multiple Regression

This method is not calculated because the multi data like the price, sale and the supply are not provided. Besides that, this method is more suitable for marketing, it is not suitable for calculation of the demand forecast.

4.5 Time-Series Decomposition

`The first step to calculate this model is to remove the short-term fluctuation from the data so that the longer-term trend and cycle components can be more clearly identified.

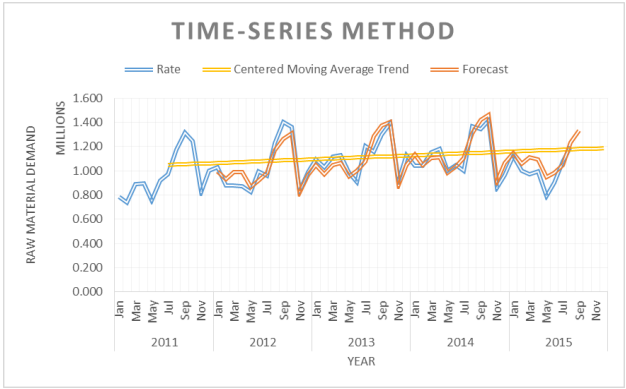

Figure 4.6, Time-Series Method.

Based on the result of Figure 4.6, the material data shows a cycle of the real data and the forecast. The red line shows the forecast data which is also calculated in the cycle. The yellow line shows the centered moving average trend using y=633.506x+72588.705. The RMSE of this method is 76, 011.89.

4.6 ARIMA (Box-Jenkins)

ARIMA is the combination method, it refers to a set for identifying, fitting and checking ARIMA models with time series data. Forecasts is followed directly from the form of the fitted model.

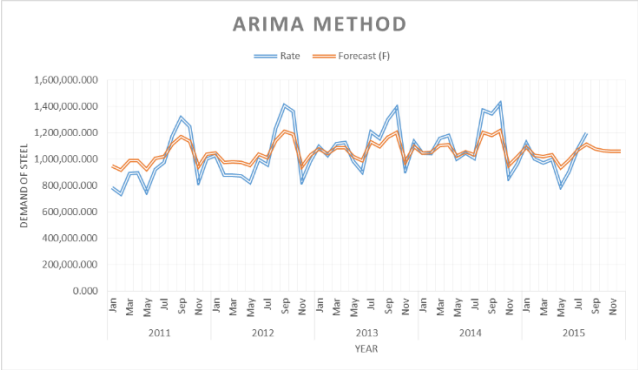

Figure 4.7, ARIMA Method.

Based on the result shown in Figure 4.7, the forecast data is not forecast over the higher point of all cycle. The table 4.9 shows the (1,1) of the (p,q) which is the ARMA. When ARMA is in the (1,1) is mean that defined by linear difference equations. ARMA (1,1) process is stationary and satisfied.

	Intercept	AR(1)	MA(1)
Coefficients	645093.4675	0.3890	0.0748
Standard Error	269300.7842	0.2567	0.2831
t-Statistic	2.3954	1.5157	0.2643
p-Value	0.0202	**0.1357**	**0.7926**
Lower 5%	1096088.5541	0.8189	0.5490
Upper 95%	194098.3809	-0.0408	-0.3993

Table 4.9, Regression Result.

The RMSE of ARIMA method is 155, 315.72.

4.7 Simulation by using Risk Simulator

To choose the best method to simulate in Risk Simulator, the comparison among the 8 methods to choose the best method is shown in Figure 4.10.

Method	RMSE	ME	MAD	MSE	TS
Moving Average	195, 219.12	10,831.86	152,647.48	38,110,503,534.85	3.76
Exponential Smoothing *Simple Exponential Smoothing	182, 438.56	49,550.27	146,336.83	33,888,989,499.00	18.62
*Holt-Winters' Exponential Smoothing	77,533.89	2,432.17	65,637.46	6,011,504,769.34	2.08
*ADRES	197, 098.15	(984.05)	153,950.63	38,847,681,761.65	(0.35)
Rgression	210, 542.70	77,193.08	162,248.23	44,328,227,146.73	26.64
Time-Series Decomposition	76, 011.89	(13,387.76)	65,579.77	5,777,806,990.12	(8.98)
ARIMA	155, 315.72	288.56	124,634.23	24,561,572,462.71	0.13

Table 4.10, The Forecast Error Comparison.

The method is the Time-Series Decomposition which is having the lower RMSE = 76, 011.89.

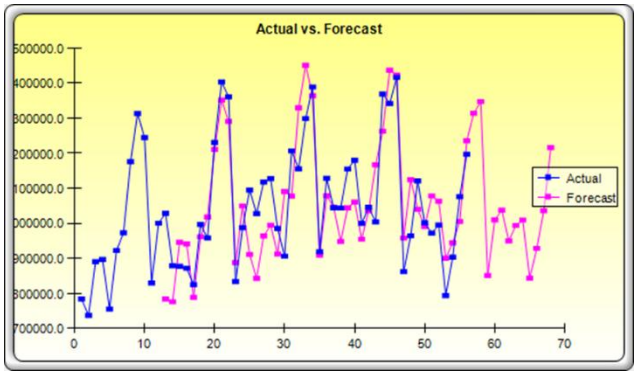

Figure 4.8, Time-Series Method by using Risk Simulator.

Figure 4.8, shows the result of Time-Series Method by using the Risk Simulator, the analysis was run with the α=0.1601, γ=0.4281, and the seasonality=12.

Table 4.9 in appendixes shows the Time-Series Method (Seasonal Additive) is the best modal. Table 4.10 shows the RMSE of the Time-Series Method in Risk Simulator is 105,065.22.

Error Measurements	
RMSE	105065.2220
MSE	11038700869.3013
MAD	87767.0777
MAPE	8.40%
Theil's U	0.6190

Table 4.11, Error Measurement.

4.8 New Model Development

The new model has been simulated using the Forecast X Software to the ARIMA new model which is the ARIMA (1,0,0) × (1,1,1) by the (p,d,q). The RMSE by this modal is 177, 309.04 which is shown in the appendix.

The ARIMA (1,0,0) × (1,1,1) model is formed by

$$(1-\phi B)(1-\Phi B^{12})\nabla_{12}X_t = (1-\Theta B^{12})a_t \quad (4.1)$$

Denoting $\nabla_{12}X_t$ by y_t it can be rewritten as

$$y_t = \phi y_{t-1} + \Phi y_{t-12} - \phi\Phi y_{t-13} + a_t - \Theta a_{t-12} \qquad (4.2)$$

Where ϕ and Φ are the nonseasonal and seasonal AR operators, respectivery, and Θ is the seasonal MA operator (Delleur, J. W., & Kavvas, M. L. 1978).

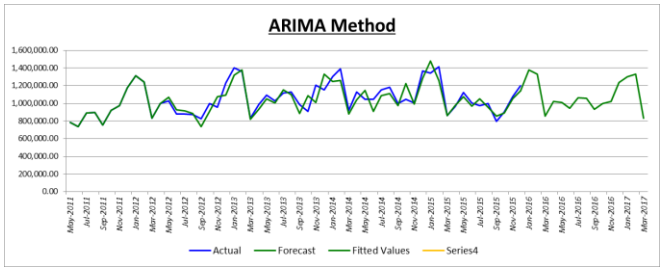

Figure 4.9, ARIMA method by using the Forecast X Software.

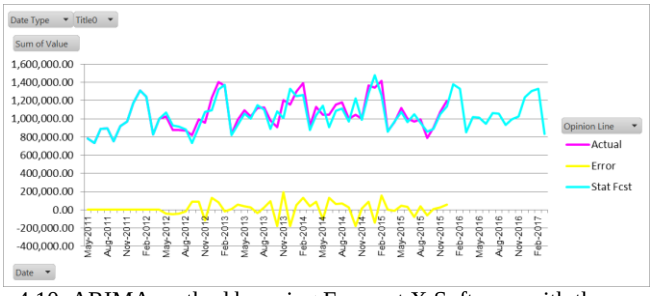

Figure 4.10, ARIMA method by using Forecast X Software with the error line.

The forecast Error of this ARIMA Method is,
RMSE = 88, 907.813
ME = 16, 082.396
MAD = 71, 659.174
MSE = 7, 904, 599, 166.297
TS = 9.875

5.0 Conclusion

Based on this research we can find that the Demand Forecasting can be simulated to the nearest forecast to estimate the demand. This may help the manager control easily the demand of the steel in the demand of the operation for the company Joon Hee MICRON Sdn. Bhd. The hypothesis is accepted from this research, which has the positive relationship between Demand Forecasting and Strategic Resource Planning.

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