A STUDY OF DEMAND FORECASTING IN ELECTRONIC MANUFACTURING INDUSTRY USING TIME-SERIES APPROACH

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A STUDY OF DEMAND FORECASTING IN ELECTRONIC MANUFACTURING INDUSTRY USING TIME-SERIES APPROACH

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A thesis submitted in fulfillment of requirements for the award of the degree of Bachelor of Industrial Technology Management (Hons).

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion this thesis is satisfactory in term of scope and quality for the award of the degree of Bachelor of Industrial Technology Management (Hons).

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis, "*A Study of Demand Forecasting in Electronic Manufacturing Industry Using Time-series Approach*", is my own except for the quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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This Final Year Project Report (FYP)

Is specially dedicated

To my beloved parents and siblings

For their

Love, Endless Support and Encouragement.

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ABSTRACT

The study of the evaluation on the forecasting techniques applied in the manufacturing industry is known as very crucial part in the operation decision making for all electronic manufacturing service industry. The objectives of this research are to evaluate the demand forecasting method used by the manufacturing company, analyses the sale data of the company using several forecasting method and lastly propose the most suitable forecasting method to the manufacturing company. The forecasting method used in the analysis involved Time Series Forecasting Method. The forecasting method was assess by using forecast error measurement tool such as Mean Absolute Deviation (MAD), Mean Squared Error (MSE), Mean Absolute Percentage Error (MAPE) and Tracking Signal. These forecast error analyses were used to monitor the forecast result of various methods. The result of this study showed that trend projection was chosen as the most suitable forecasting method as it produces the most accurate result and least forecast error. Demand forecasting plays a critical role in every business especially in manufacturing industry. Most of the operations decisions in manufacturing industry are based on some kind of forecast for future demand. As a result, manufacturing company pay highly attention towards demand forecasting process and this study has devoted attention to this particular issue.

ABSTRAK

Kajian ini adalah mengenai analisa kaedah ramalan yang diterapkan di dalam industri pembuatan. Kaedah ramalan yang diterapkan di dalam industri pembuatan memberikan kepentingan kepada bahagian pengurusan untuk membuat keputusan yang tepat di dalam ramalan mengenai produk syarikat. Objektif kajian ini adalah untuk mengakses kaedah ramalan yang paling sesuai bagi industri pembuatan elektrik untuk memenuhi permintaan pelanggan. Kaedah ramalan yang sesuai untuk menganalisis maklumat yang diperolehi adalah dengan menggunakan kaedah ramalan "Time Series". Seterusnya, dalam menentukan ketepatan kaedah ramalan, "Mean Absolute Deviation", "Mean Squared Error", "Mean Absolute Percentage Error" and "Tracking Signal" digunakan untuk menganalisa ketepatan kaedah ramalan. Hasil kajian ini menunjukkan "Trend Projection" adalah kaedah ramalan yang paling tepat untuk diterapkan di dalam industri pembuatan elektrik untuk pengurusan pengeluaran. Ramalan untuk permintaan produk oleh pelanggan sangat penting dalam menguruskan pengeluaran produk dan pembentukan modal. Kebanyakan operasi di industri pembuatan bergantung kepada ramalan terhadap produk untuk masa kelak. Oleh itu, industri pembuatan memberi perhatian tinggi terhadap ramalan mengenai permintaan produk dan kajian ini mengakses analisis terhadap isu ini.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Forecasting plays a crucial role in every functional activity of the firm. It is predicting and estimating future demand to provide demand forecasts for company. Many companies needed a reliable forecast as they do not know their future demands and have to rely on demand forecasts to plan for long term business strategies and ensuring that the supply chain operates effectively on a day-to-day basis. Therefore forecasting is one of the important planning tools in decision making (Yassin and Ramlan, 2011) and important issue for manufacturing companies (Kalchschmidt, 2007). The ability to forecast future demand accurately now plays an important part in the need for organization to integrate the internal and external supply chain (Bowersox, Closs and Cooper, 1999; Sanders and Ritzman, 2004).

Supply chain management if conducted in a proper way can add value for smoothen operations of the manufacturing process that can help in maintaining the delivery schedule. Strategies to produce better quality product in an accurate timing are extremely important in manufacturing companies, however meeting the increasing time demands of customers will become important. Strategies to shorter the production lead time will be the strategic focus for at least the next 10 years. Measurement for time in seconds, minutes, hours, days, months or years has been increasingly emphasized among firms, especially the manufacturing companies (Kaes and Azeem, 2009). In every supply chain management, demand forecasting act as an important method to sustain profitability in business operation. Therefore,

improving demand forecasting performance has long been a concern of every management level involved in every industry (Amrstrong and Grohman, 1972).

In manufacturing companies, several decision making processes need accurate forecasts in order to choose proper actions relevant to production planning, sales budgeting, transportation mode and schedule delivery arrangement. In order to streamlining the manufacturing process, practitioners and academics have placed a particular attention to how forecasting can be improved to increase forecast accuracy. (Armstrong, 2001; Caniato, Kalchschmidt, Verganti, 2002). Research shows that improved forecasting techniques are useful mainly for different organization department including decision making and planning processes (Winklehofer, Diamantopoulos and Witt, 1996). However, not all the techniques are applicable for each category of the materials used in production line. Proper implementation of the appropriate technique with the right parts is very much important for accurate demand forecasting.

Thall (1992) and Agrawal and Schorling (1997) indicated that accurate demand forecasting plays a significant role in profitable production operations while poor forecasting results in understock or overstock that directly affects the cost and management of the inventory. The common practice of forecasting demand in supply chain planning ranging from simple naive methods to sophisticated quantitative methods and from simple judgemental methods to complex qualitative methods are available. Qualitative methods rely on managerial judgment and opinions by each profession as different individuals can provide different perspective from the same information. Qualitative methods are used when data are unreliable or unavailable or when time is limited. Quantitative methods rely on mathematical models and depend on the historical data that can be combined into reliable estimation of the future. Quantitative practices include time series decomposition, exponential smoothing, time series regression and autoregressive and integrated moving average (ARIMA) models. In forecasting, each method is suited to different conditions (Waddell and Sohal, 1994).

According to Bon and Leng (2009), most of manufacturing companies in Malaysia determine demand forecast for their production using judgmental forecast or common

quantitative forecast method such as simple moving average and simple exponential smoothing method. Kerkkanen, Korpela, Huiskonen (2009) stated that the imitation of concepts, targets and principle of forecasting method among consumer product, risk for unrealistic accuracy targets and deceptive error measures. Therefore special circumstance should be monitored and analysed before any methods or techniques are applied (Wilson and Keating, 2009). Therefore, the objectives of this paper is to analyses the demand forecasting techniques adopted by a manufacturing company and implement different demand forecasting method for the products demand. Then, evaluation among different methods is conducted to determine the best suitable technique to forecast the demand parts for the company.

1.2 PROBLEM STATEMENT

Today's competitive global market caused every industry to pay more attention on the materials flow along the supply chain. However, the uncertainty that exist in the supply chain in a complex ways has targeted the benefits of accurate and effective forecasting. Many companies have put many efforts by making significant improvements by using a suitable approach that supports and facilitates the process of supply chain management. All the forecasting techniques including qualitative and quantitative approaches are designed to produce accurate, timely estimates of future sale demand in the presence of uncertainty. In manufacturing company, they often will use more than one forecasting approach in different functional department. Applications of forecasting techniques in estimating production demand can be improved as the planners can make the judgmental decision based on the historical data and have gains experience yet the forecast may not be accurate as there is always a risk associated with the planners' experience such as expectations and hopes, among which may introduce bias and error.

Demand forecasting is considered as an important issue in manufacturing company regardless of whether it is the responsibility of functional department such as finance, marketing, sales and logistics. Most of the company understand the proper forecasting process provide the opportunity to better understand market dynamics and consumers'

behaviours, provide the company's department with useful analysis and information and reduce uncertainty on future operation. The adoption of appropriate forecasting techniques in the business process can help to reduce cost and increase the delivery performance because of forecast accuracy improves.

In fact, improved demand forecasting accuracy can help the company in monetary savings, enhanced competitiveness, improves channel relationships and customer satisfaction. Many planners have recognized the importance of accurate demand forecasts to efficient inventory management in the supply chain process. Research has found that successful inventory management is dependent on the accurate estimation of the spare parts sale in manufacturing industry. Accurate demand forecasting generates great profits in manufacturing operations and inaccurate forecasting caused understock or overstock that has a significant impact on the profitability and competitive advantage of the manufacturer.

In general, sales department developed the monthly forecast based on their operational knowledge and experiences and final forecast is determined after regular discussion with other functional teams. Most of the companies know that their demand forecasts are not accurate but they never think of better forecasting approaches and ignore the issue. As a result, manufacturers tend to hold high inventories as their concern is not to run out of stocks when purchase orders are received from customers regularly.

When deal with demand uncertainty, the most common practice used by the planner is by building and increasing inventory. Each departments planning and control their production and operation by building more safety stocks as they are not confident in the demand forecast. In the supply chain, whenever each stage creates its own buffers, the inventories skyrocket. Many large companies do not know the exact quantities of goods they required to manufacture, transport and store in the inventory yet they are lack of alertness to take up the other better forecasting techniques and technologies that can reduce the inventory burden.

1.3 RESEARCH OBJECTIVES

1) Evaluate the demand forecasting method used by the manufacturing company.
2) Analyses the sale data of the company using several forecasting method.
3) Propose the most suitable forecasting method to the manufacturing company.

1.4 RESEARCH QUESTIONS

1) What is the forecasting method adopted by the company in the sale department?
2) Which forecasting techniques can be used to analyse the sale data?
3) What is the most suitable forecasting method can be used by the company?

1.5 SCOPE OF THE STUDY

This study focuses on demand forecasting in purchasing department of a manufacturing company. It aims to provide an overview and analysis of the current demand forecasting techniques adopted by the forecasters particularly for the demand of high technology product in the company. This study focuses on Jabil Company, small and medium electronic manufacturing services companies in Malaysia and the demand forecasts for the manufacturing parts used in its production line. This study will use the data collected from Jabil Company in Penang, Bayan Lepas area. The data includes the order unit and sales unit of the product for twelve consecutive months. There are lots of products needed in the production line that planners require forecast updates almost once every month. Due to time limitation, this study focused on one of the popular product only.

Then, this study also document the demand forecast results by using the several different forecasting approaches based on the sales data. Besides, the objective of this study is to suggest the implementation and adoption of the most suitable demand forecasting method to help the company in managing the inventory and production planning. This study aims to provide prediction for further part demand in the short to medium term for the planners in determining purchase order. The planners from the purchasing department will be

proposed with more efficient forecasting technique that enable better management of the inventory and improve the performance of total supply chain planning. The planners that used the most suitable forecasting approach will be able to balance the actual demand and supply, reduce the mismatch between actual demands and forecast by improving understock and overstock problems with day-to-day operations.

1.6 SIGNIFICANCE OF THE STUDY

Forecasting the product demand is important to every supplier, manufacturer and retailer in their relative field. Forecasts of future product demand will decide the amount that should be purchased, produced and delivered to the end user. Demand forecasts are basic need since a time period is taken along business operations process which from the flow of suppliers' raw materials until finished goods to the customers. Many companies cannot simply react to the demand upon customer's requirement in a short period.

In general, they must anticipate and determine for future demand in order to have quick response to customer orders every time they occur. It is a common practice in most of the manufacturing firm "make to stock" instead of "make to order" which they estimate the quantity and create inventories to store finished goods in advance. Therefore, as the firm received customer order, they can be fulfilled the requirement immediately while no waiting time is needed to process customer order along the supply chain. In supply chain, an order cycle usually taken weeks or months to be processed by part suppliers and sub-assemblers, then manufacture of the product before eventually deliver the order to the final customers.

This study will benefit and help the planners in purchasing department of electronic manufacturing company to have a better understanding to the demand forecasting methods over inventory planning. Demand forecasting act as a useful tool for the planners to deploy the right amount of inventory in anticipate to customer order as well as fulfills the needs of the production at the same time without causing any additional cost in inventory accumulation of the company. Planners can manage the movement of the resources in time with the presence of demand forecast throughout the supply chain.

This study serves the manufacturing company as their reference in production planning as well as product scheduling. A manufacturing firm cannot operate in wilderness as crucial decisions have to be determined on what product to be made and quantities to be produced. The key to these decisions lies upon its estimation of product demand in the future. In case the demand forecasted might going to increase, production capability can be enlarge in order to supply the growing demand at the right timing.

1.7 OPERATIONAL DEFINITION

Demand forecasting: In the supply chain process, demand forecasting tends to predict sales and the demand of products so that the resources can be acquired, stocked or produced in the right quantities in order to smoothen the firm's value adding operations.

Demand uncertainty: Situation concern how far will the firms exist in the market and future products development or shrink over a period of time? Will the firm's competitive advantage be affected when new competitors emerge and enter the market?

Inventory: The value of materials and goods owned by an organization to support production which including raw materials, subassemblies and work in process, activities involved repair, and maintenance or for sale or customer service which consist of merchandise, finished goods and spare parts.

Safety stock: When there is mismatch the actual demand and forecast, between actual and expected shipment time and emergencies, inventory act as buffer to fulfill the unexpected demand.

Supply chain: A supply chain in comprise of all parties including the manufacturer and suppliers transporters, warehouses and retailers, directly or indirectly, in fulfilling a customer requirement.

Qualitative approaches: Qualitative approaches consist of subjective inputs, which often do not contain precise numerical description. It involved the soft information such as human factors, personal opinions and judgment in the forecasting process.

Quantitative approaches: Quantitative approaches comprise of either the presence of historical data or the development of complicated models that attempt to utilize causal (explanatory) variables to create a forecast.

1.8 EXPECTED RESULT

This research aims to identify and evaluate the current forecasting method adopted by the manufacturing company. This research will provide evidence on how to improve the forecast for product demand by using several forecasting approaches. By adopting the most suitable technique in the forecasting process, it will contribute to the most accurate and unbiased forecast result to improve the inventory management and production planning in the company.

CHAPTER 2

LITERATURE REVIEW

2.1 Analyses The Implementation Of Demand Forecasting In Industry

Today's supply chains for high technology products increase in complexity and the whole supply chain has a significant impact on the effective operation management, demand forecasting has become imperative tool for the production of high technology product. However, due to rapid technological change and various product modifications, it caused the demand for high technology product fluctuates and the demand is difficult to forecasted (Yelland, 2010).

It is a challenging business in manufacturing and producing modern high technology products such as computers. There is a fierce competition where shorter product life cycle, components are usually expensive and likely to obsolete in a short period throughout the supply chain in manufacturing industry. According to Lapide (2006), demand forecasting act as a critical role in supply chain management for every company in manufacturing high technology products market. This study focuses on one such market participant - Jabil Company, small and medium electronic manufacturing services companies in Malaysia and on forecasts of the demand for the manufacturing parts used in its supply chain.

Jabil Company provides customized design, manufacturing, distribution and after sale services for many large companies. Jabil successfully creates customer and supplier value through advanced IT supply chain solutions and local procurement, improved inventory management, precise planning and lowest possible cost solutions. Besides, Jabil manages

commodities, market information and practice sourcing through a centralized procurement office which is located in Malaysia. Adoption of systematic global supply chain management process together with supply chain support allows Jabil to manage supply chain management growth continually without increasing the overall supply chain system's cost and complexity, enhancing competitiveness through efficiency as well as general ease-of-doing-business with the company's customer.

Demand forecasting is generally acted as a significant role in most of the manufacturing companies (Armstrong, 2001). Forecasting parts demand is vital to supplier, manufacturer or distributor. Forecasts of future part demand will measure the appropriate quantities that should be purchased, manufactured and shipped. Demand forecasts are crucial since the basic operations process involved a period of time interval taken as the suppliers' raw materials has to move to customers with finished goods. Generally, manufacturers operate by anticipate and plan for future demand so that they can react immediately to customer orders as they occured. Wu, Chiag, Wu and Tu, (2004) claimed the role of forecasting existed in controlling the relationship between customer demand and finished goods flow. They further asserted that forecasting for demand parts continues to be a key concern in many organisation. In general practice, accurate demand forecasts lead to efficient operations and high levels of customer service, while inaccurate forecasts will certainly caused performance of production decrease with high cost operations and poor customer service (The Context of Demand Forecasting, n.d.).

According to Katz, Pagell and Bloodgood (2003), inaccurate forecasting affected the performance of supply chain efficiency so it was a necessity to reduce such inefficiency with some strategies. Taylor and Fearne (2006) described inaccurate forecasting in the food supply chain as a significant problem that caused negative impacts on supply chain efficiency and the product flow. Besides, the improvement in demand forecasting was identified as a key factor for enhancing supply chain operations in food industry supply chain (Aghazadeh, 2004). Furthermore, to the continuing challenges of forecasted inaccuracy, it has an impact on major rescheduling and additional cost difficulties for manufacturing (Ebert and Lee,

1995) and may caused the logistic performance in the way that affected delivery timeliness and quality (Kalchschmidt and Zotteri, 2007).

Forecasting management is a complicated issue and companies can determine to control different aspects to improve their forecasting process (Mentzer and Bienstock, 1998; Moon, Mentzer and Smith, 2003). Forecasting management included the decisions on information acquisition procedures and tools as the company know what data should be selected, the way it should be selected, method to be used by organization by assigning responsible person for forecasting demand parts and their role, ways, cross function cooperation and collaboration between company in order to create a shared forecast by gathering different kinds of information within the company or supply network, joint development of forecasts and assessment of accuracy by selecting the appropriate metric and determine proper incentive mechanisms (Danese and Kalchschmidt, 2011). However, some research claimed that the common approach to forecasting demand parts depends on defining a demand forecasting unit (DFU) and evaluate historical information to define the average, cyclical, trend and seasonal demand parts (SAP, 1996).

Figure below shows the framework of the demand forecasting process. Demand forecasting in a manufacturing industry can be explained in terms of input transactions, historical data and master data. There are various purposes for the demand forecast that has been made. The forecast produced is used as input for material requirements planning in sourcing the parts needed as well as for financial planning. As a result, the outcome of the forecasting process is determined in units of quantities and value form.

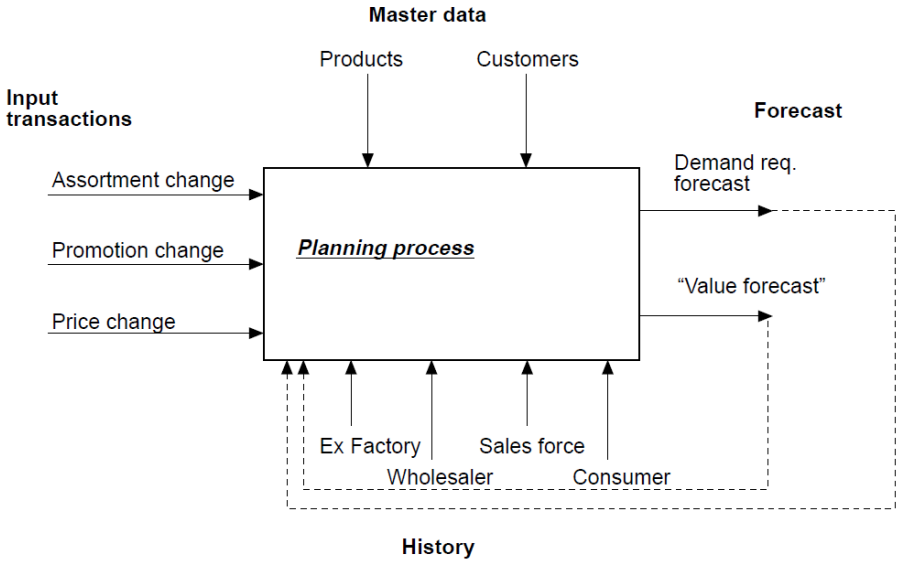


Chart of forecasting process in competitive market (Holmström, 1998).

The input processes are the activities the company makes to determine demand. The key input transactions including assortment, promotion and price change. The master production schedule data comes from product and customer requirement in demand forecasting process. The requirement to provide feedback to sales and marketing personnel is important with the purpose to improve the forecasting process. Therefore, it is crucial to be able to identify with demand on levels that helps the sales and marketing personnel to manage the supply chain process. (Holmström, 1998).

Then, historical data can be obtained from different sources of the supply chain stage. There is fierce competitive in business environment, reaction to change in the market has to be done quickly and the reduction of buffer stock in inventory level is inevitable. Responsiveness could be improved in the case where the demand is determined close to customer definition as possible. As a result, the ideal sales history is developed for the end consumer comes in the way of point-of-sales scanning data (Holmström, 1998). On the other hand, forecasting based on historical data expected the pattern happened previously tends to happened again in the future. The basic operation of historical information is supported by current knowledge comprise of certain specific trend, level, event than requires the expectation that history will be repeated (Fulcher, 1998, p. 92).

Some researcher found out that during the process in developing sale forecast, contextual information that included the experts with the market, product and buyer knowledge are important data to be obtained. The contextual information usually could be assessed by looking through the company's sales and marketing departments (Reese, 2001). Every department able to minimize their problems depends on different purpose and forecasts as well as enhances the accuracy of sale forecast when the company' sales and marketing personnel were involved in forecasting process (Fosnaught, 1999; Helms, Ettkin and Chapman, 2000).

2.2 Determine The Forecasting Variables And Factors In The Forecasting Process

Determine the way to improve the forecasting process is a complicated work for companies, as it can be improved by implementing different approaches and by controlling over several factors, identify the methods that can be used to develop a forecast and also to the company of the entire process. Nevertheless, company commonly has limited resources and do not has the ability to change everything in the same time. Therefore, they need standard rule in determine the priorities in the process to improve forecasting performance. As the company objectives is to improve their performance by using a more efficient forecasting process, forecasting variables related to performance has to be identify and the importance of each variables has to be considered. Other than forecasting variables, conceptual models, depends on systematic evaluation of the relation between particular forecasting variables and performance of company was proven to be far apart (Danese and Kalchschmidt, 2011).

There are various elements establish and organize the forecasting process and different framework has been studied. According to Armstrong (1987), forecasting process comprise of four dimensions: forecasting techniques, data availability, analysis of uncertainty and cost and benefits. In other words, forecasting method of different type and number of techniques used followed by whether a management information system database is established which gather information from different paths where the characteristics and constraint of the forecast are given as well as forecasting expense and the outcomes

constituted forecasting model. Then, the other framework characterize forecasting process consists of three variables including the forecaster and decision tools, information transfers and technical characteristics of the forecast (Fildes and Hastings 1994). In technical view, the model concerned about the planner's training and purpose of the forecast for various functional groups, information used on the environment as well as accuracy and bias were considered. Then, Moon et al (2003) considered a forecasting model based on four variables: functional integration where emphasis the coordination between functional areas, type of techniques adopted, central systems in providing information and performance assessment for accuracy. In order to compete in business environment, many organizations redesigned the demand forecasting process with the aims to obtain more accurate forecast result and connectivity among production plans.

No matter which technique implemented in forecasting, there are eight key principles that need to be consider such as accuracy forecasts, the time horizons of forecasting, technological change, barriers to entry, dissemination of information, elasticity of demand, consumer versus industrial products and aggregate versus disaggregate. Most companies understand that their forecasts are not accurate, but they did not find solution to solve the issue by continue applied the wrong forecast in their business process (Helms, et al., 2000). In business environment, there is acceptable error tolerated by manufacturer which the standard is not the same within every company. Besides, forecasting accuracy decreases when the time horizon increases. As a general rule, long range forecasts will be less accurate than the short range forecast because the greater the chance that developed patterns, trends and relationships fluctuates with time change, thereby invalidating forecasts (Smith, Herbig, Milewicz and Golden, 1996). Most of the business environment change cannot be predict for a long term expectation. Since the business environment change in a furious way that they cannot be predicted, the change in environment impact on business also cannot be predicted.

2.3 Determine The Approaches To Demand Forecasting

There is existence of various forecasting techniques that can be applied in different areas for the last few decades. With the availability of various different forecasting

techniques, it can be broadly divide into two basic categories which are quantitative approaches and qualitative approaches.

Quantitative techniques are classified into two basic kinds such as time-series methods and explanatory methods. Time-series methods create forecasts based on the historical information while explanatory methods gather other factors. A time-series techniques is a time-ordered sequence of studies taken at specific time intervals. Every firm used different approaches based on the purpose of the forecast yet most of the firms used explanatory method as it considered additional factor rather than sales data only. Qualitative methods tend to predict future when no historical data is available to forecast demand product (Cavanagh, n.d.). A judgmental forecast which is qualitative depends on subjective inputs from different sources. Quantitative forecasting methods include the Naive forecasting method, the simple moving average method, the weighted moving average method and the exponential smoothing method. In fact, forecasts result are never exactly accurate therefore there is always some way for improvement.

There are many different approaches in demand forecasting, some research have totally different perception about the relationship between the forecasting adoption and accuracy (Wacker and Sprague, 1998). There are enormous arguments about the effectiveness of quantitative approaches that included exponential smoothing or regression analysis and qualitative approaches such as the judgment forecast and Delphi method. It is very important to select the suitable approach for the forecasting purpose where judgment forecast will be chosen when there is little or no historical data is given and the business activity has high demand uncertainty and could be affected by previous business activities (Sanders and Manrodt, 2003). On the other hand, quantitative approaches are likely to be chosen in the case that a few forecast need to be develop for variety of products when the good quality data exist and demand show a stable pattern (Makridakis, Wheelwright and Hyndman, 2008). Besides, combination of quantitative and qualitative method also has been proposed in the demand forecasting process (Sanders and Ritzman, 2001; Franses and Legerstee, 2009).

In general, many companies realized that when they implemented the quantitative and assortment forecasting methods, the performance is not exactly better than the adoption of qualitative approaches in their firms, hence researchers believed that the implementation of forecasting techniques whether quantitative or qualitative is always useful for the firms as it helps to minimize the judgmental bias and the influence of inappropriate information (Makridakis et al., 2008). Research of sale forecasting method generally claimed that qualitative methods are preferable to be used by firms rather than quantitative methods; a wide range of research support the effectiveness of quantitative forecasting methods in most situations instead (Dalrymple, 1987). However, it is clear that not every type of methods is suitable for different materials type in firms for production. It is a crucial step to adopt the suitable techniques in the forecasting process in order to obtain accurate demand forecasting.

Among the forecasting techniques, the quantitative method shown the characteristics of being objective, stable, able to process enormous data and take account of correlation between different variables. Huge amount of data is required in this method, therefore when there is some change in the data that are not integrated in the model, the forecast result cannot be accurate. On the contrast, the qualitative method can combine the general knowledge of the experts in particular field, expertise experiences and judgment which is known as contextual information to develop forecast. Judgmental approaches often caused forecasting errors due to the different expertise's opinions has inherent bias. However, this forecasting method has inherent biases that cause forecasting errors.

In supply chain management, the most common forecasting demand method include the implementation of a statistical software system that incorporates a basic univariate forecasting technique, like exponential smoothing, to generate an initial forecast (Fildes, Goodwin, Lawrence and Nikolopoulos, 2009). In real business environment, the common method and various research involves exponential smoothing, time series decomposition, time series regression as well as autoregressive and integrated moving average (ARIMA) models.

Nowadays, the business competition is becoming fiercer and various time series forecasting techniques have been proposed. According to De Gooijer and Hyndman (2005), time series forecasting software tools commonly offer a enormous of methods, some of which offer the user the determine the parameters automatically. In real business environment, it is a fact that user might need to forecast the various techniques of the time series in order to generate the reliable forecast for decision making. It is crucial to provide the firms an expert forecasting system that capable to deal with the automatic parameterisation of specific forecasting models or expert system that able to select the most appropriate forecasting technique from a set of forecasting models in the system. Time series forecasting models are conducted to identify trends, cycles, seasonal pattern and random variables that might affect the forecast accuracy. The analysis is integrated to generate forecast for the firms. As for the product with consistent demand with available historical sale, the analysis based on time series models are very accurate while for new products, the forecasts are inaccurate (Smith et al, 1996).

Although there are numerous types of approaches used to forecast demand, in real business environment the time-series approach is usually the most suitable and the most accurate technique to develop the large amount of short-term range, SKU level, generally disaggregated forecasts needed to manage a physical distribution system in a specific short time horizon. On the contrary, time series techniques sometime may not provide very accurate forecast result. As the general knowledge or the insight about future activities such as price change are expected within the firm, the forecast by expert opinion or relational is appropriate when the forecaster has incorporate other variables in forecasting process (The context of demand forecasting, n.d.).

The application of every forecasting method has the objectives to generate accurate and unbiased prediction of the future event with the existence of uncertainty. Generally, firms will integrate two or more forecasting techniques to produce an accurate demand forecast. The implementation of forecasting approaches can be better used as the forecaster acquired experience and complexity, yet there is a factor to be considered with the

forecaster's judgment and opinion might has the risk to inherent bias and error (Smith et al, 1996).

A set of forecasts usually treated as accurate only if the forecast errors which shown in the set of specific values are considered small based on the measurement on the forecasts result. For the measurement of forecast accuracy, there is apparently a gap between error and noise. These two factors cannot be related to each other as there is distinction between them. Customers' part demand is polluted by noise from various factors such as promotional activity, marketing, competitor activity, out of stocks, retail merchandising effectiveness. It is truth that noise in the demand data is real and cannot be monitored which will have impact in the forecasts result because real-world noise data is unpredictable. On the contrary, we generate the errors that we observe as we generate the forecasts; improved forecasts will produce smaller errors (The context of demand forecasting, n.d).

2.4 Examine The Accuracy Of Various Forecasting Techniques

Kerkkanen et. al (2009) indicated that there was different types of effect in production planning and inventory level with different types of forecast errors. Choosing the most suitable forecast measurement is a necessity in order to get better forecast accuracy. From the previous research, there are several assessment of forecast accuracy and recommendation have been made by several studies on which tools should be used in evaluate the accuracy of the forecast techniques. There are some measures for forecasting performance and the most popular ones involves means absolute percentage error (MAPE), mean squared error (MSE), mean absolute deviation (MAD), cumulative error and average error or bias (Mentzer and Moon, 2005). In the contest of time series forecasting, these forecasting measurement tools are completely general. They can be implemented to any type of forecast errors regardless of what method had been used to create the forecasts (The Context of Demand Forecasting, n.d.).

The Mean Absolute Deviation (MAD) indicated the average magnitude of the errors without regard to whether the errors represented under-forecasts or over-forecasts. The MAD

is a common and popular error measure in inventory control systems as it is easy to determine and simple enough to understand. On the other hand, the statistical characteristics of the MAD are not suitable for application in probability-based decision models.

Formula of MAD:

$$\mathbf{MAD} = \frac{\sum |\mathbf{Actual - Forecast}|}{\mathbf{n}} = \frac{\sum |\mathbf{Error}|}{\mathbf{n}}$$

Then, The Mean Squared Error (MSE) is determined by averaging the squares of the forecast errors. In the condition of unbiased set of forecasts, the MSE is considered equivalent of the variance of the forecast errors. MSE is the statistically applicable tools of forecast errors. In measuring performance of forecasts, several forecasting procedures accuracy will be compared based on the basis of MSE and the forecasting technique that has minimize the MSE of the forecasts will be identified.

Formula of MSE:

$$\mathbf{MSE} = \frac{\sum (\mathbf{Actual - Forecast})^2}{\mathbf{n}} = \frac{\sum (\mathbf{Error})^2}{\mathbf{n}}$$

Next, the Root Mean Squared Error (RMSE) represented the square root of the MSE. In a set of unbiased forecasts, RMSE stand for the standard deviation of the forecast errors. The RMSE is presented in the same measurement units in the same way as the demand data thus is more easily to interpret unlike MSE that is unintuitive to interpret. In adequately large data sets, the RMSE is shown to be proportional to the MAD, in the case the constant of proportionality depends upon the underlying probability distribution of the forecast errors.

Furthermore, Mean Absolute Percent Error (MAPE) showed the absolute magnitude of each forecast error as a percentage of the actual demand and then average the percentages. In real business environment, MAPE is considered as the most popular measurement tools for forecasting accuracy (Mentzer and Bienstock, 1998).

Formula of MAPE:

$$\mathbf{MAPE} = \frac{\sum \frac{|\mathbf{Actual - Forecast}|}{\mathbf{Actual}} * 100\%}{\mathbf{n}}$$

According to Lam, Mui and Yuen (2001), mean absolute percentage error (MAPE) has gained popularity as a forecast measurement tool because it is intuitive to interpret and understandable. It is also helpful to express the accuracy of a model to planners or other non technical users (Chu, 1998). It is a measure applied by several companies and consistent with that implemented by previous surveys. In practice, measuring forecast errors enhanced forecast accuracy (Mentzer and Moon, 2005) and the most suitable forecasting method comes with smallest forecast error. (Ryu, 2002).

The forecast error is generally normally distributed, which shows that the forecast is in control. Tracking Signal is used to assess the larger deviation up and down change in actual value in forecast error. It is a measure used to monitor if the actual demand does not perform the assumptions in the forecast about the distribution and predict level in the demand profile. Tracking signal reflect if there is a persistent tendency for actual value to be exceed a certain limit. Although the control limits range from ± 3 to ± 8, the acceptable limits for tracking signal are usually within 4, which correspond to three standard deviations. (Chockalingam, 2009).

Tracking Signal is computed by dividing the cumulative error by MAD. The cumulative error can be positive and negative, so the Tracking Signal can be positive or negative as well.

Formula of Tracking Signal:

$$\textbf{Tracking Signal} = \Sigma\ (\text{At-Ft})/\text{MAD}$$

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Research methodology plays a critical role in the research. This chapter will determine and explains the appropriate research methodology to investigate the research problems and accomplish the research objectives in this study. It delivers the overview of the research design and the data collection method as well as the data analysis method.

3.2 RESEARCH DESIGN

Research design is required before we begins to collect the data or analyses the data. It plays an important role in order to ensure that the data gathered enables the researchers to answer the initial questions as clear as possible. It is generally designed to answer the research questions, to assess a program, to evaluate a theory or to explain some phenomenon accurately.

In this research, the case study method was used as the research method. According to Yin (2003), case study methodology provides for the retention of meaningful aspects of real-life context such as organizational and managerial processes. It is also applicable to an evaluation as in this study as it allows the use of qualitative and quantitative evidence. Single case study used in this research. Single case study was used to verify or investigate a theory or to represent a special or extreme case. Besides, Yin (2003) claimed that single case study

suitable for revelatory cases when a researcher may have access to a phenomenon that was formerly inaccessible.

In this research, the objective is to identify and analyses the demand forecasting method used by the manufacturing company in the purchasing department. The planner was the targeted respondent as the person will involve in purchasing process, supporting the process of material procurement, managing the material flow for the operation at the production line. Interview session with the planner was used to gather information and data for this research. The interview questions were designed based on data and information obtained from literature review. The evaluation of the demand forecasting method adopted by the manufacturing company and the assessment of several demand forecasting techniques suitable for the use of the purchasing department in the company were discussed.

3.3 INTERVIEW

An interview is a method to gather information of individuals who has the knowledge and experiences in the field of the research. This method allows the finding of clarification and elaboration and provides more latitude for investigation (May, 2001). Hence, face-to-face interview was used in data collection process in this research. The interview was designed in the form of flexible, iterative and continuous to ensure that the interviewee provides their opinion and conception easily. The planners' team in the purchasing department was interviewed so that there were no gaps in the data as different planners worked with different parts.

The interviews with the planners' team aimed to identify the current forecasting method used by the team for the different parts. The interview was concentrate on understanding the characteristics of forecasting variables that affected the forecasting process. It also focused on the problem of the demand forecast for the product which has a significant impact on the inventory management of the company.

3.4 DATA COLLECTION TECHNIQUES

Data collection plays a critical role in any type of research study. The information and forecasting process were collected in several ways, including literature reviews, conference article and useful reference book to ensure any relevant studies or methods from local and international research will be utilized and determine specific issues for development in this research design. Accurate data collection is vital to maintain the integrity of research to prevent the issues of inability to answer research questions accurately, inability to repeat and clarify the research and inadequate findings resulting in wasted resources.

Therefore, primary and secondary date sources were used in this research. Primary data were obtained through interview and secondary data were gained through academic literature review, journal and some online articles. For the primary data, it is required to go to the company to interview the particular planners' team in order to collect the data effectively. Data relevant to the forecasting process by the company were gathered. In this study, the data that were involved consists of the company's monthly order unit and monthly sale unit for the sample product.

3.5 DATA ANALYSIS TECHNIQUES

Data analysis comprise of examining, categorizing, tabulating, testing or otherwise combining both the quantitative and qualitative evidence to deliver they initial objectives of a study (Yin, 2003).

Time series forecast approaches were used to analyses the data collected from the manufacturing company. A time series is a time-ordered sequence of observations taken at regular intervals such as hourly, daily, weekly, monthly or annually. The data may be measurements of demand, earnings, profits, shipments or productivity. Forecasting approaches based on time-series data are made on the assumption that future events of the series can be predicted from past events.

Analysis of time-series data requires the forecaster to identify the underlying behavior of the series. This can often be determined by merely plotting the data and visually measuring the plot. There might be one or more patterns appeared including trends, seasonal variations, cycles or random and irregular variations. Time series methods require historical data only on the variable to be forecast. They are appropriate to be used when little or no information about the factors affecting a variable to be forecast.

In this study, the data analyses were carry out using five individual forecasting methods. The forecasting results were developed using POM Software. The forecasting results were evaluated using various forecasting measurement.

3.6 THE FORECASTING METHODS

The forecasting methods that were used in this study is the simple moving average, weighted moving average, exponential smoothing, trend-adjusted exponential smoothing and the simple linear projection method.

- Simple Moving Average

A simple moving average forecast uses a number of the most recent actual historical data values in generating a forecast. The moving average forecast can be computed using the following equation:

$$F_t = MA_n = \frac{\sum_{i=1}^{n} A_{t-i}}{n} = \frac{A_{t-n} + \ldots + A_{t-2} + A_{t-1}}{n}$$

Where

F_t = Forecast for time period t

MA_n = n period moving average

A_{t-i} = Actual value in period $t - i$

n = Number of periods (data points) in the moving average

- Weighted Moving Average

A weighted average is similar to a moving average, except that it assigns more weight to the most recent values in a time series. For instance, the most recent value might be assigned a weight of .40, the next most recent value a weight of .30, the next after that a weight of .20 and the next after that a weight of .10. Note that the weights must sum to 1.00, and that the heaviest weights are assigned to the most recent values.

$$F_t = w_t(A_t) + w_{t-1}(A_{t-1}) + \ldots + w_{t-n}(A_{t-n})$$

Where

w_t = Weight for the period t, w_{t-1} = Weight for period t -1, etc .

A_t = Actual value in period t, A_{t-1} = Actual value for period t -1, etc.

- Exponential Smoothing.

Exponential smoothing is a sophisticated weighted averaging method that is still relatively easy to use and understand. Each new forecast is based on the previous forecast plus a percentage of the difference between that forecast and the actual value of the series at that point. That is:

Next forecast = Previous forecast + α (Actual - Previous forecast)

where (Actual - Previous forecast) represents the forecast error and α is a percentage of the error. It is present as:

$$F_t = F_{t-1} + \alpha (A_{t-1} - F_{t-1})$$

Where

F_t = Forecast for period t

F_{t-1} = Forecast for the previous period (i.e., period $t-1$)

α = Smoothing constant (percentage)

A_{t-1} = Actual demand or sales for the previous period

- Trend-Adjusted Exponential Smoothing

A variation of simple exponential smoothing can be used when a time series exhibits a linear trend. It is called trend-adjusted exponential smoothing to differentiate it from simple exponential smoothing, which is appropriate only when data vary around an average or have step or gradual changes. If a series exhibits trend and simple smoothing is used on it, the

forecasts will all lag the trend: If the data are increasing, each forecast will be too low; if decreasing, each forecast will be too high.

The trend-adjusted forecast (TAF) consists of two elements: a smoothed error and a trend factor.

$$TAF_{t+1} = S_t + T_t$$

Where

S_t = Previous forecast plus smoothed error

T_t = Current trend estimate

And

$$S_t = TAF_t + \alpha (A_t - TAF_t)$$

$$T_t = T_{t-1} + \beta (TAF_t - TAF_{t-1} - T_{t-1})$$

Where

α = Smoothing constant for average

β = Smoothing constant for trend

- Simple Linear Projection

The simplest and most widely used form of regression involves a linear relationship between two variables. The object in linear regression is to obtain an equation of a straight line that minimizes the sum of squared vertical deviations of data points from the line (i.e., the least squares criterion). This least squares line has the equation:

$$y_c = a + bx$$

Where

y_c =Predicted (dependent) variable

x = Predictor (independent) variable

b = Slope of the line

a =Value of y_c when $x = 0$ (i.e., the height of the line at the y intercept)

The coefficients a and b of the line is based on the following two equations:

$$b = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2}$$

$$a = \frac{\Sigma y - b\Sigma x}{n} \text{ or } \bar{y} - b\bar{x}$$

Where n =Number of paired observations

3.7 ACCURACY MEASUREMENT

In order to determine the model that shows the best performance, the study needs some way to compare the accuracy of forecasting techniques over a number of periods. Several methods were recommended to summarize the error developed by a particular forecasting method. In this study, four forecast error measurement tool involved Mean Absolute Deviation (MAD), Mean Squared Error (MSE), Mean Absolute Percentage Error (MAPE) and Tracking Signal were used.

The formula for MAD:

$$\mathbf{MAD} = \frac{\sum |\,\mathbf{Actual - Forecast}\,|}{\mathbf{n}} = \frac{\sum |\,\mathbf{Error}\,|}{\mathbf{n}}$$

The formula for MSE:

$$\mathbf{MSE} = \frac{\sum (\mathbf{Actual - Forecast})^2}{\mathbf{n}} = \frac{\sum (\mathbf{Error})^2}{\mathbf{n}}$$

The formula for MAPE:

$$\mathbf{MAPE} = \frac{\sum \frac{|\,\mathbf{Actual - Forecast}\,|}{\mathbf{Actual}} * 100\%}{\mathbf{n}}$$

The formula for Tracking Signal:

$$\mathbf{Tracking\ Signal} = \Sigma\ (\mathbf{At\text{-}Ft})/\mathbf{MAD}$$

3.8 POM SOFTWARE

In order to carry out the forecasting calculation job, the POM software was used. It is software that is reliable and acknowledged by the industry as well as the academic field. Therefore, it is the appropriate software to be used in this study. Many companies of all sizes use the POM software successfully today in their operation and production management. Besides, the POM software also owned recognized reputation in the academic industry.

In order to present a clear picture about the operation of the POM software in forecasting, the general operation steps are provided as below.

Step 1: Start POM Windows and select the "Forecasting" from the [Module] menu.

Step 2: In the [File] tool, click "New" and select the "Time Series Analysis" forecasting method.

Step 3: In the data input screen, specific the forecasting title and the number of past period demand information as well as the row label.

Step 4: On the data input matrix screen, select the "Method" tool. There will be listing of all the "Time Series" models including Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend and Linear Regression. Next, select the forecasting technique that need to analyses the data.

Step 5: In the data capture dialog box, identify and enter the data that need to analyze and specify the data contain dates as well as the descriptive label.

Step 6: Select [Solve] and the report including forecast results, details and error analysis and graph will appear**.**

CHAPTER 4

DATA COLLECTION AND ANALYSIS

4.1 INTRODUCTION

This chapter shows the findings and the results of the forecasting analysis conducted on the data collected. It is structured by showing the variables in determine the forecasting model, steps in forecasting system, results of several forecasting model followed by the results of the forecast error. At the end of the chapter, there is a summary of the entire forecasting technique model used.

4.2 DATA COLLECTION

4.2.1 Primary Data Sources

This study analyses the data collected from a Company J (Manufacturing Industry) for several forecasting models. The information that were collected during the interviewed including implementation of the forecasting system, steps taken in the forecasting process, variables involved in selecting the forecasting method, generation of the forecast by cross functional department and difficulties encountered in development of forecast result by the Company J.

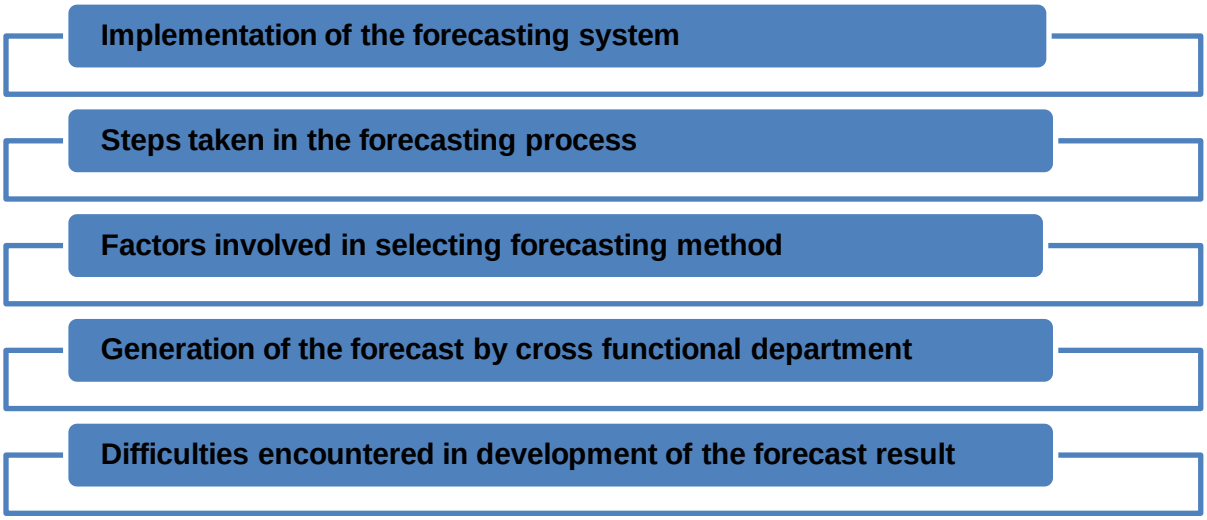


Figure 4.1 Forecasting Information from Company J

4.2.1.1 Implementation of the forecasting system

In Company J, the adoption of the forecasting approaches mostly applied for production planning at their plant. The demand forecast was developed by planners in order to manage their operation, capacity and scheduling system. Every planner was assigned with different product so that they can estimate the expected demand that will be generated from their activities and actions needed to be taken and their expected impact. There are a few forecasting techniques adopted by the planner depends on which forecasting model set in system. At the purchasing department, the forecasting system commonly used is the normal MRP system.

Material Requirements Planning (MRP) can be defined as a computer-based production planning and inventory control system. MRP is focus on the production scheduling and inventory control. It is a material control system that attempts to keep inventory at appropriate levels to confirm that required materials are available when needed. The MRP system in Company J aims to simultaneously achieve three goals involving availability of raw materials for production and finish products are available for customers' delivery, maintain adequate inventory levels as well as plan manufacturing and purchasing activities.

4.2.1.2 Steps taken in the forecasting process

When focus on sales forecasting and demand planning, company J are coordinated and adopted six simple steps. The seven steps taken in the process of forecasting including determine the forecasting objectives, decide what to be forecast, set the time frame, collect the data for forecasting, choose the forecasting model, develop the forecast and compare events with the forecasts. This process is illustrated in Figure 4.2, which shows detail steps taken in developing the forecast. These six steps aims to speed planning cycles, increase forecast accuracy, decrease inventory costs, reduce stockouts and improve customer satisfaction.

There are few activities are as crucial to the success of a firm as demand planning and sales forecasting. The difference between suitable and exquisite demand planning and sales forecasting has the ability to drive a company's market position and competitiveness beyond than their competitors. In conjunction to gather and analyze data to generate the forecast, it depends on the customer’s requirement as some required weekly order while some required monthly order.

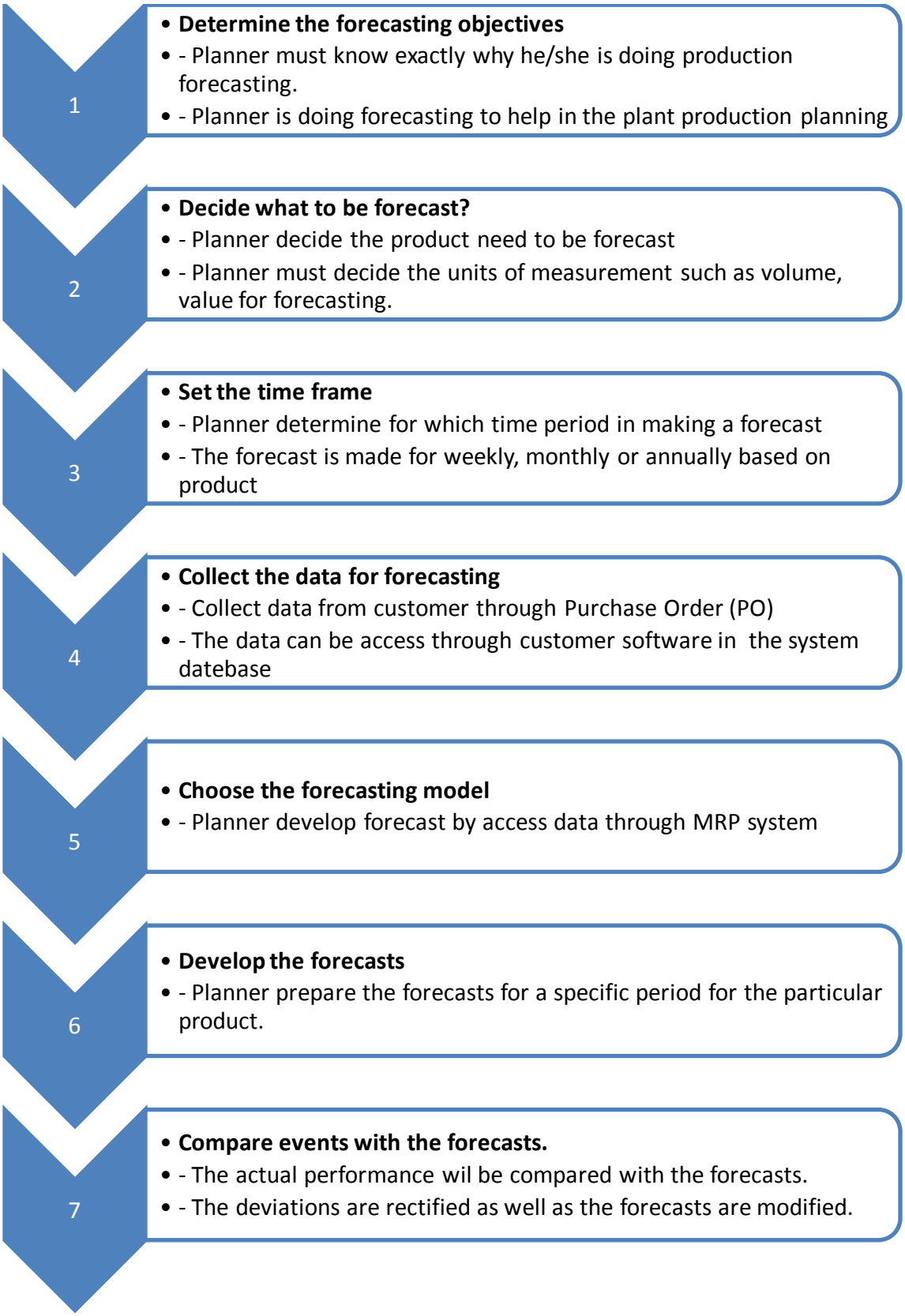


Figure 4.2: Steps taken in the Forecasting Process by Company J

4.2.1.3 Factors involved in selecting forecasting method

The forecaster has an important role to play in technique selection. The selection of forecasting techniques depends on factors such as availability of historical data, the time frame to be forecast, the cost of the forecast, the degree of accuracy and the time period for making the analysis. Company J consider the availability of past sale data and ease of use as an important information before prepare the forecast. Moreover, when the planner wants to forecast with reference to a certain product, it will consider the product life cycle stage for which it is making the forecast. The maturity of a product has a direct influence on data availability and the possibility of building relationships between the factors therefore the stage in life cycle essentially determine of the forecasting technique to be implement.

4.2.1.4 Generation of the forecast by cross-functional department

In the past few years, Company J has placed significant attention on the concept of inter-company collaboration in the area of production planning and demand forecasting. The Business Department is working with Purchasing Department in creating the demand forecast for their customer. Both department involved design a business plan that takes into account their individual team strategies and defined product category objectives. Information on planned business event are used by business department to create an initial sales forecast and then communicated to the planners to be used as a baseline for the development of customer order forecast. By doing collaborative forecasting, purchasing department able to access better information on important demand drivers, such as promotions.

4.2.1.4 Difficulties encountered in development of the forecast result

In the generation of demand forecast, the planner in Company J faced quite a lot issues. There are many factors need to consider such as disaster and competitors that will influence the result of the forecast. Whenever there is disaster happened, the production line will be

negatively affected and the productivity will be decreased. At the same time, the forecast that have been made earlier will not be accurate and new forecast need to be developed by adding new variable in a short period. Moreover, when competitors produce a new product it will affect market trend as well as affect the company sale. The forecast performance will be affected and planner has to act fast to overcome the inaccurate in the forecast result. These are the difficulties often encountered by the planners which make it take every consideration into forecast generation.

4.2.1.5 Time-Series Forecasting Method

This time series forecasting method analysis is based on the assumption that the future events are follow by the past event. For example, if we are predicting the demand of electronic component, we use the past demand for electronic component to develop the forecast. Examples of time series model including simple moving average, weighted moving average and exponential smoothing. A time series is just collection of past values of the variable being predicted. It is also known as naive methods. The objective of time series aims to isolate patterns in past data. This method is quite accurate where future is expected to be similar to past.

In Company J, planners used quantitative forecasting method when the historical data are available. This study analyse the historical data provided by Company J. The data of the product demand for Product A were collected for two years from 2011 to 2012. The data collected was the actual demand and the forecast result from the customer and purchasing department. This study involved analysis of the demand forecasting for Product A. The demand forecasting in this study was focus on year 2012. Therefore Time Series forecasting model was chosen as the forecasting techniques in this study.

The table below are the actual historical data obtained from the Company J (electronic manufacturing components) for the Product A (electronic component). The data below showed actual demand in units and the forecast demand result in twelve consecutive months.

Table 4.1: Actual Demand and Forecast Demand for Product A in 2012

Months	Actual Demand (units)	Forecasted Demand (units)
January	390	450
February	440	480
March	390	360
April	370	300
May	430	340
June	470	430
July	440	480
August	500	510
September	550	460
October	630	480
November	560	590
December	530	480

Table 4.2: Actual Demand and Forecast Demand for Product A in 2011

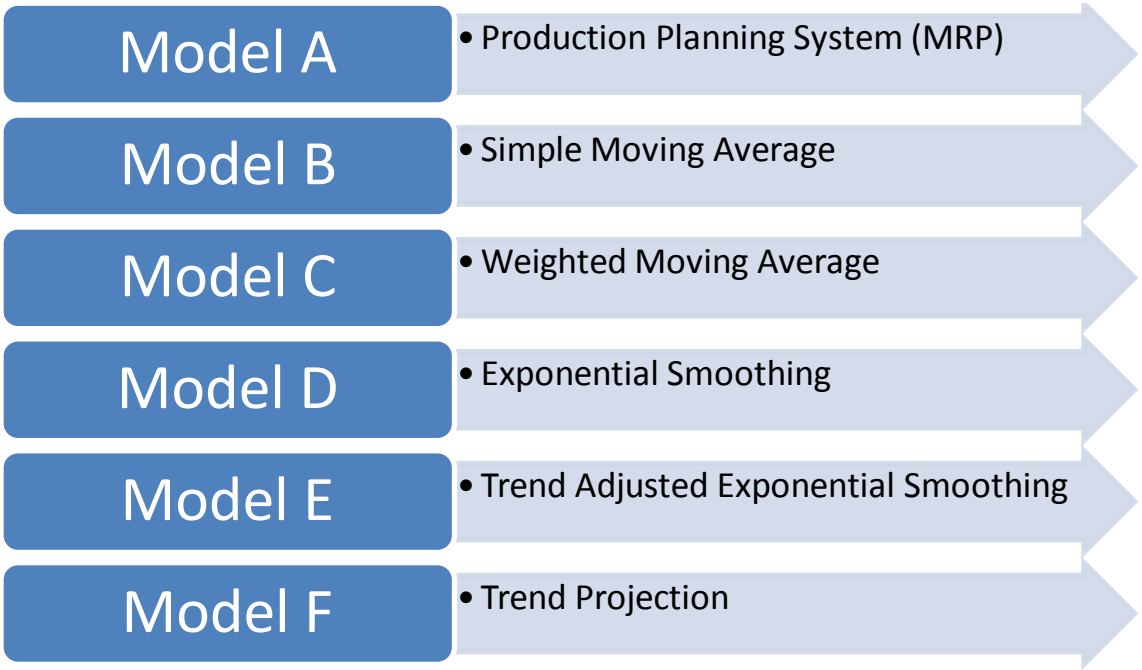
Months	Actual Demand (units)	Forecasted Demand (units)
January	380	340
February	250	230
March	280	300
April	390	270
May	260	210
June	370	320
July	330	390
August	420	380
September	450	330
October	470	400
November	430	470
December	410	480

4.3 DATA ANALYSIS

Based on the historical data given by the Company A, analysis of the time-series forecasting model will be used in this study. Time series methods are popularly known to forecaster that carry out a statistical analysis of historical data to make forecasts for the future. The underlying assumption of the model is that past relations will continue to present in the future. The different methods vary mostly in the way in which the past values are directly related to the forecasted ones. Therefore, the time-series model involved in this study is simple moving average, weighted moving average, exponential smoothing, exponential smoothing with trend and trend projection.

In this study, time series model indicates the past historical values of the variables under consideration. The values of the variables has to be considered in a time-series are calculated at specified intervals of time period. The interval is measured in monthly manner in Company J.

Table 4.3: Models of Forecasting Methods



In this study, there are four important time-related factors need to be considered in the analysis of a time series models.

There are four important factors including trend, seasonality, cycle and random variation. First of all, trend related to the long-term constant changes in data like demand growth and decline in market shares. Then, seasonal variations occurred might be periodic in time-series which appear due to consuming patterns during different period of a year. Next, cyclical variations occur followed by periods of expansion and contraction. The business cycle may vary includes a wide variety of factors such as economic and life cycle of product. Last but not least, random variations present fluctuations in the data which cannot be related to the trend, seasonal or cyclical factors. The reasons for such variations caused by factors like a communal clash and sudden weather changes.

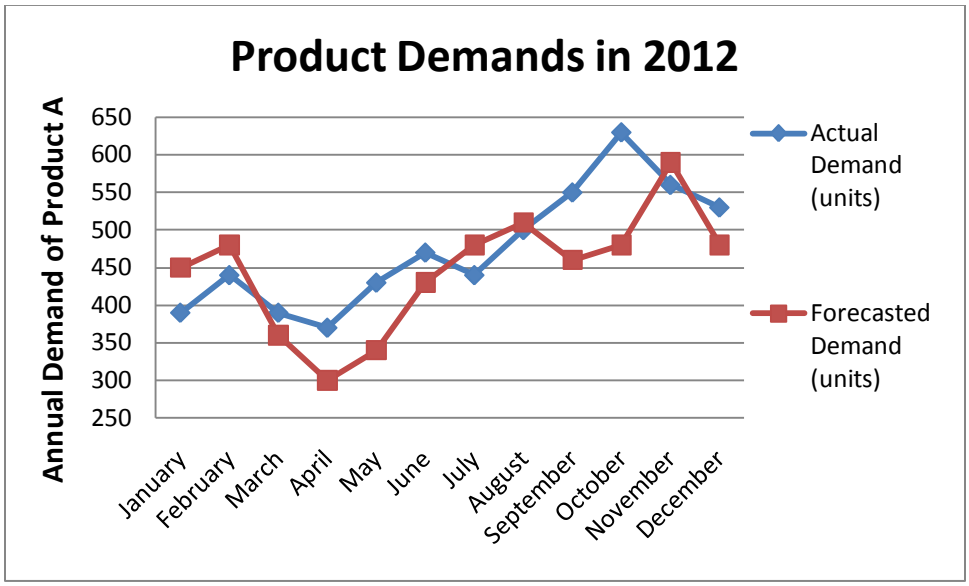


Figure 4.3: Graph for Product A in 2012

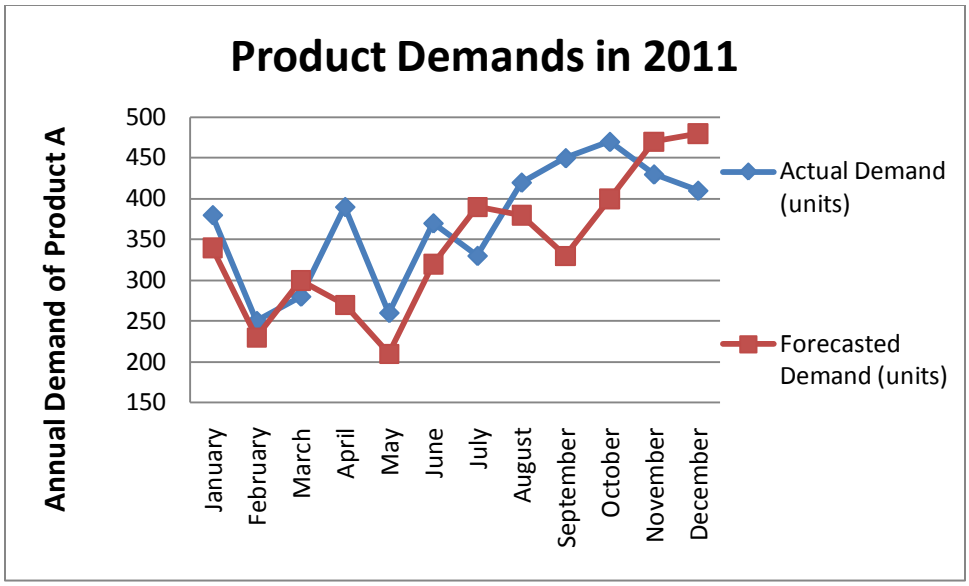


Figure 4.4: Graph for Product A in 2011

The historical data in the demand for Product A is illustrated in the line graph form. Line graph is useful for spotting the movement or trend of past value over time and be plotted with two scales to present a comparison of set of values with different time periods. From the graphs show above, it is obviously large discrepancies between the actual demand and forecasted demand in year 2011 and 2012. The forecasted demand result is not accurate compared to the actual demand. As we can see from the actual demand graph, there is a trend on the demand for both 2011 and 2012. Trend refers to the gradual upward and downward movement of the data over time. Besides, we can also see the seasonality variations in the product demand. It is a pattern that repeats itself after a period of months on Product A.

4.3.1 Forecasting model generation for Product A

The forecasting model adopted by the Company J was assessing MRP system to get the demand forecast result. Planners used the previous customer required order to obtain the current demand forecast. The forecast result developed will be used in the production planning system monthly. In this study, different time series forecasting model will be used by applying same past data.

4.3.1.1 Forecasting model generation by Company J (Model A)

The forecasting model implemented by the planner in Company J was assessing through MRP system based on previous Purchase Order from customer. Planner monitored the customer order into the system and develops the demand forecast in short term period. Customer loaded the Purchase Order into their own system and the planner transferred all the data into MRP system to obtain the forecast result.

Months	Actual Demand (units)	Forecasted Demand (units)
January	390	450
February	440	480
March	390	360
April	370	300
May	430	340
June	470	430
July	440	480
August	500	510
September	550	460
October	630	480
November	560	590
December	530	480

Table 4.4 Forecasting model generated by Company J

4.3.1.2 Simple Moving Average (Model B)

A simple moving average forecast uses a two month moving average to generate a forecast for demand by applied actual historical data. In application of this model, the moving average will produce a better estimate of the mean in the time series if the mean is constant or change slowly by averaging the past two months data. The moving average forecast can be computed using the following equation:

$$F_t = MA_n = \frac{\sum_{i=1}^{n} A_{t-i}}{n} = \frac{A_{t-n}+\ldots+A_{t-2}+A_{t-1}}{n}$$

F_t = Forecast for time period t

MA_n = n period moving average

A_{t-i} = Actual value in period $t - i$

n = Number of periods (data points) in the moving average

Months	Actual Demand (units)	Forecast Demand (units)
January	390	
February	440	
March	390	415
April	370	415
May	430	380
June	470	400
July	440	450
August	500	455
September	550	470
October	630	525
November	560	590
December	530	595

Table 4.5: Two- months Moving Average Forecasting Method (Model B)

4.3.1.3 Weighted Moving Average (Model C)

A weighted moving average model is similar to a moving average, except that it assigns more weight to the most recent values in a time series. For instance, the most recent value has been assigned a weight of .60 and the next most recent value a weight of .40. There are trend emerging for the product demand therefore this model are more responsive to react to the actual demand.

$$F_t = w_t (A_t) + w_{t-1} (A_{t-1}) + \ldots + w_{t-n} (A_{t-n})$$

w_t = Weight for the period t, w_{t-1} = Weight for period t -1

A_t = Actual value in period t, A_{t-1} = Actual value for period t -1

Weighted choose for this study are 0.6 demand for last month + 0.4 demand last two month = 1 (sum of the weight)

Months	Actual Demand (units)	Forecast Demand (units)
January	390	
February	440	
March	390	420
April	370	410
May	430	378
June	470	406
July	440	454
August	500	452
September	550	476
October	630	530
November	560	598
December	530	588

Table 4.6: Weighted Moving Average Forecasting Method (Model C)

4.3.1.4 Exponential Smoothing (Model D)

Exponential smoothing is a sophisticated weighted averaging method that is still relatively easy to use and understand. It is fairly used in forecasting method and involves a little keeping record data. That is:

Next forecast = Previous forecast + α (Actual - Previous forecast)

where (Actual - Previous forecast) represents the forecast error and α is a percentage of the error. It is present as:

$$F_t = F_{t-1} + \alpha (A_{t-1} - F_{t-1})$$

Where

F_t = Forecast for period t

F_{t-1} = Forecast for the previous period (i.e., period $t-1$)

α = Smoothing constant (percentage)

A_{t-1} = Actual demand or sales for the previous period

In order to get the most accurate forecast, smoothing constant, α used in this study is 0.5.

Months	Actual Demand (units)	Forecast Demand (units)
January	390	
February	440	390
March	390	415
April	370	402.5
May	430	386.25
June	470	408.13
July	440	439.06
August	500	439.53
September	550	469.77
October	630	509.88
November	560	569.94
December	530	564.97

Table 4.7: Exponential Smoothing Forecasting Method (Model D)

4.3.1.5 Trend Adjusted Exponential Smoothing (Model E)

This trend-adjusted exponential smoothing differentiates trends from simple exponential smoothing, which is appropriate only when data vary around an average or have step or gradual changes. This is because the added trend adjustment factor makes it possible for the forecast more quickly approach the actual value. Smoothing constant for $\beta = 0.6$ is higher than α, because a high β is more responsive to change the trend.

The trend-adjusted forecast (TAF) consists of two elements: a smoothed error and a trend factor.

$$TAF_{t+1} = S_t + T_t$$

S_t = Previous forecast plus smoothed error

T_t = Current trend estimate

And

$$S_t = TAF_t + \alpha (A_t - TAF_t)$$

$$T_t = T_{t-1} + \beta (TAF_t - TAF_{t-1} - T_{t-1})$$

Where

α = Smoothing constant for average

β = Smoothing constant for trend

Months	Actual Demand (units)	Forecast Demand (units)
January	390	
February	440	390
March	390	422.5
April	370	408.88
May	430	386.23
June	470	411.47
July	440	452.88
August	500	456.64
September	550	495.03
October	630	547.47
November	560	626.07
December	530	620.46

Table 4.8: Trend-Adjusted Exponential Smoothing Forecasting Method (Model E)

4.3.1.6 Trend Projection (Model F)

Trend projection is the time series forecasting method that fits a trend line to a series of past data points and then projects the line into future for forecast. The trend projection used historical data by applying the formula:

$$Y=b_o + b_1X$$

Y = predicted value
$\mathbf{b_o}$ = intercept
$\mathbf{b_1}$ **=** slope of the line
X = time period (1, 2, 3.....n)

Months	Actual Demand (units)	Forecast Demand (units)
January	390	371.54
February	440	390.35
March	390	409.16
April	370	427.97
May	430	446.78
June	470	465.59
July	440	484.41
August	500	503.22
September	550	522.03
October	630	540.84
November	560	559.65
December	530	578.46

Table 4.9: Trend Projection Forecasting Method (Model F)

4.3.2 Comparison of The Actual Demand and Various Models In The Forecasting Method

A few graphs have been plotted from the forecast result of Model A to Model F against the actual demand for Product A. The graphs below show the comparison between the actual demands, Model A (forecast demand by Company J) and each Model.

Figure 4.5: Comparison between the Actual Demand and the Forecasting Model generate by Company J (Model A)

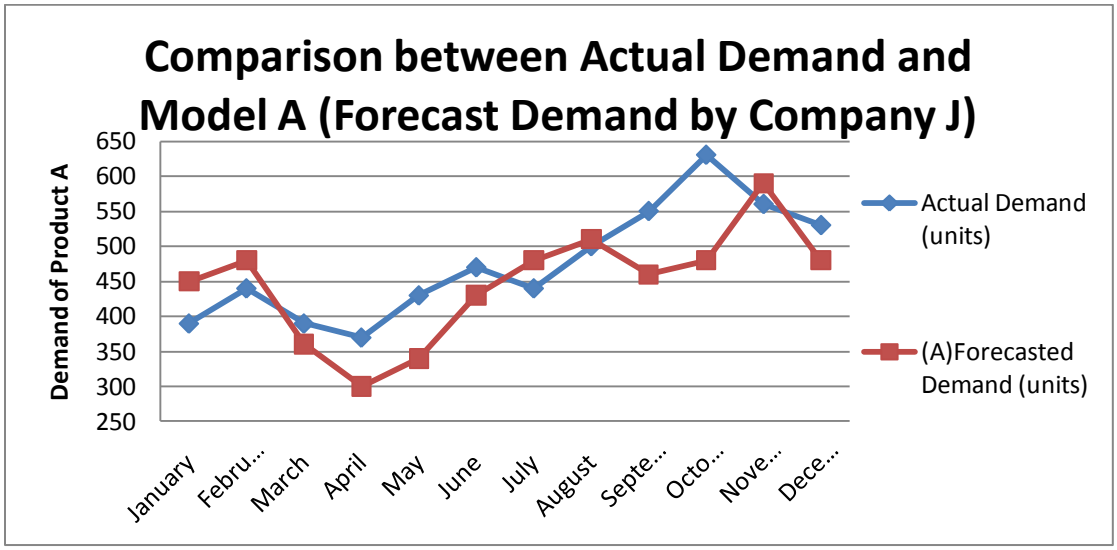


Figure 4.6: Comparison between the Actual Demand, Model A and Model B

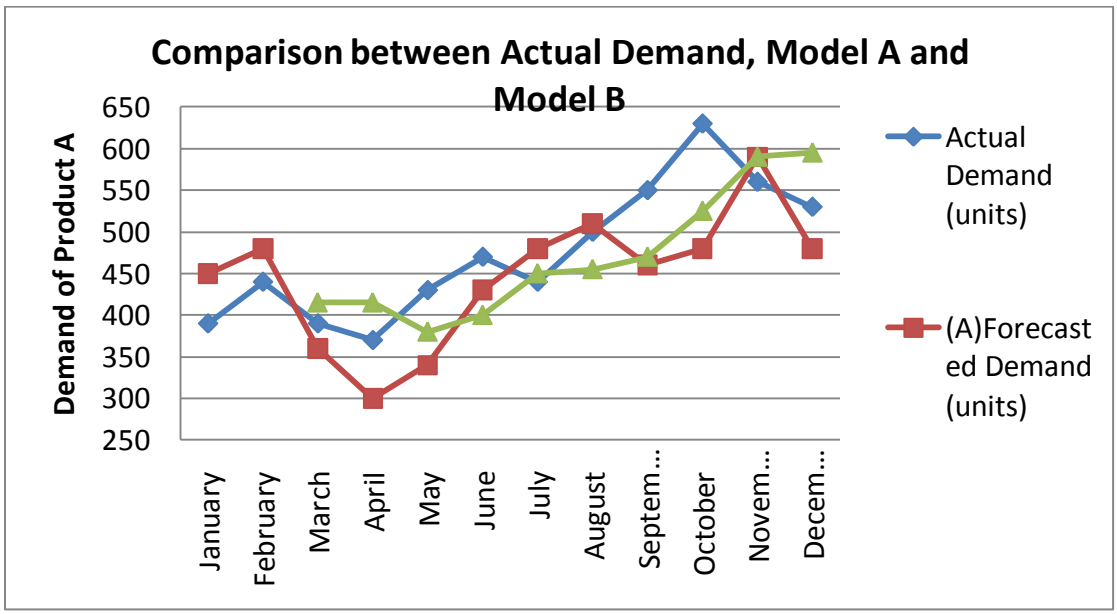


Figure 4.7: Comparison between the Actual Demand, Model A and Model C

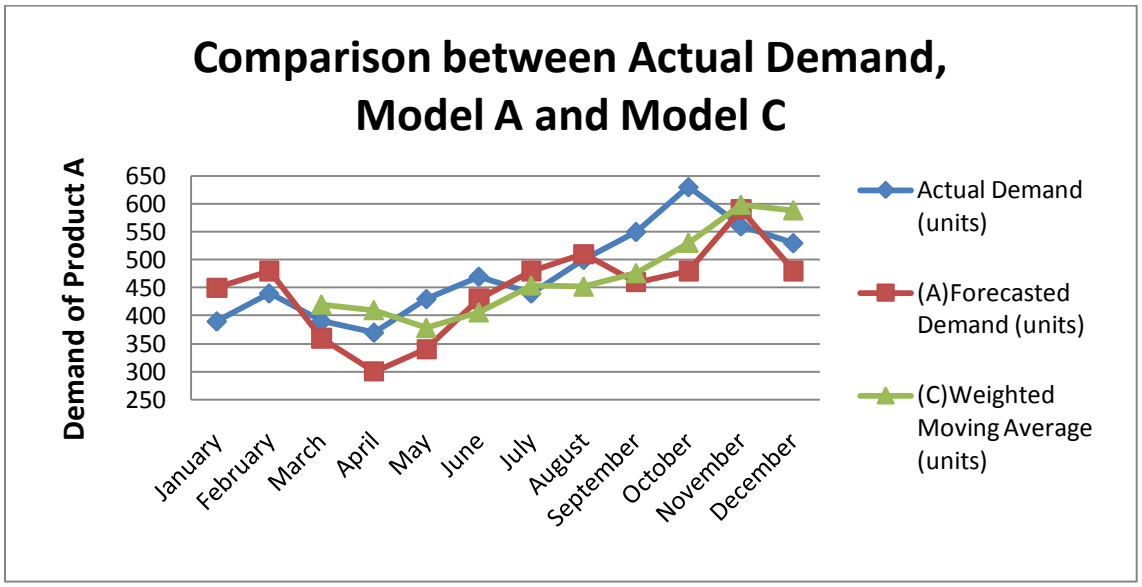


Figure 4.8: Comparison between the Actual Demand, Model A and Model D

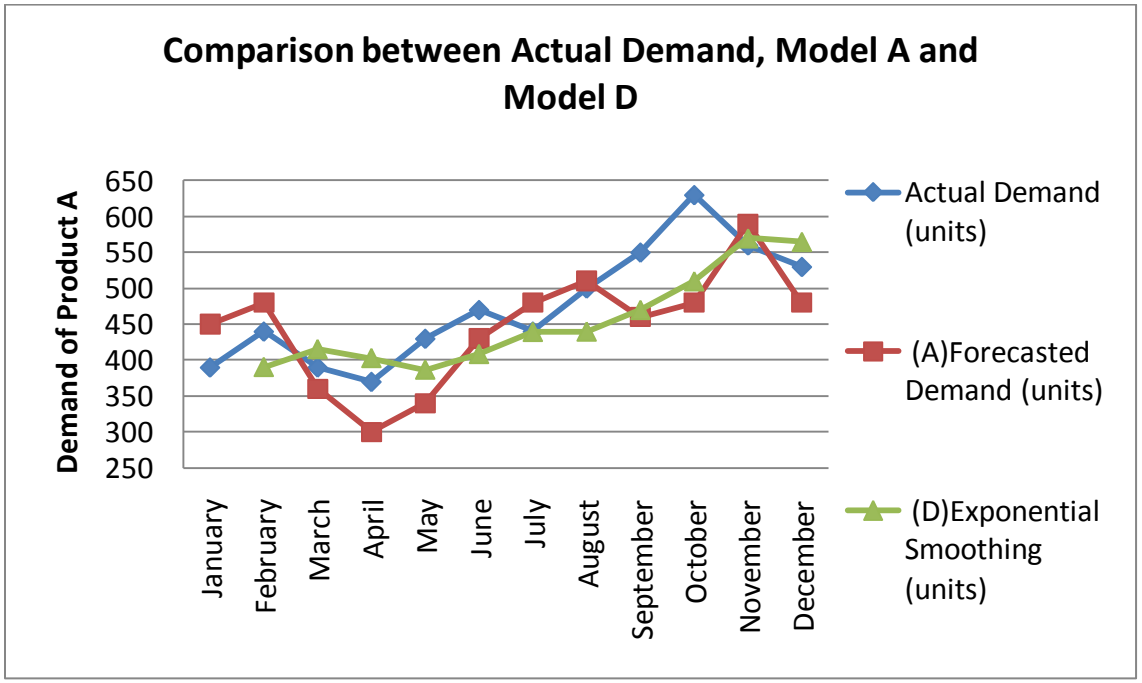


Figure 4.9: Comparison between the Actual Demand, Model A and Model E

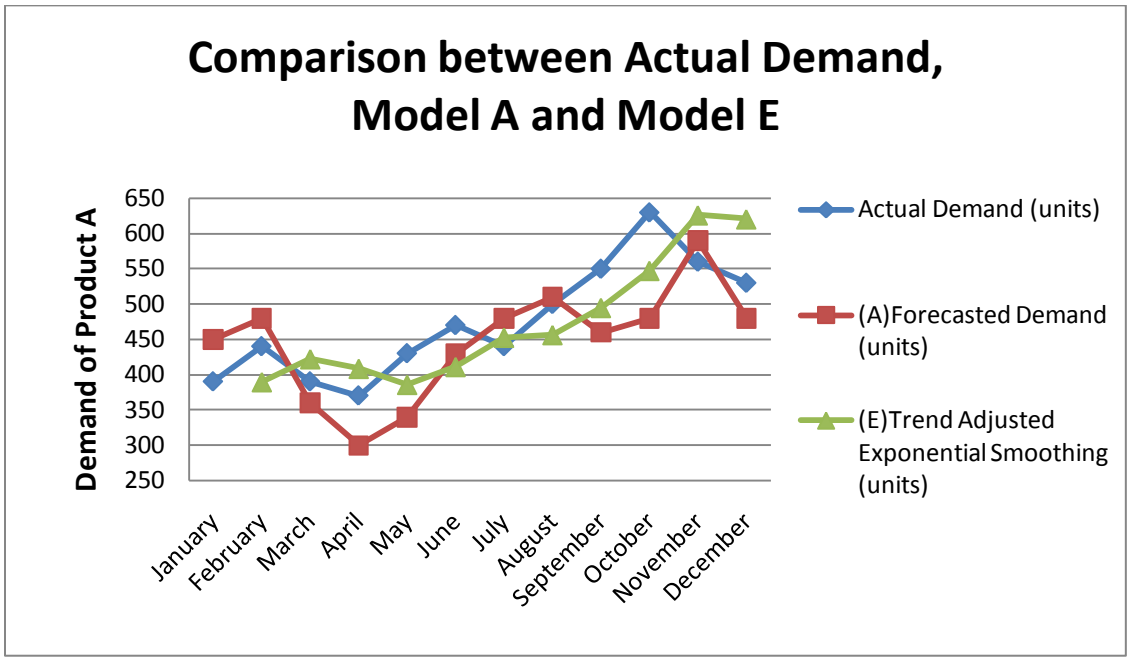
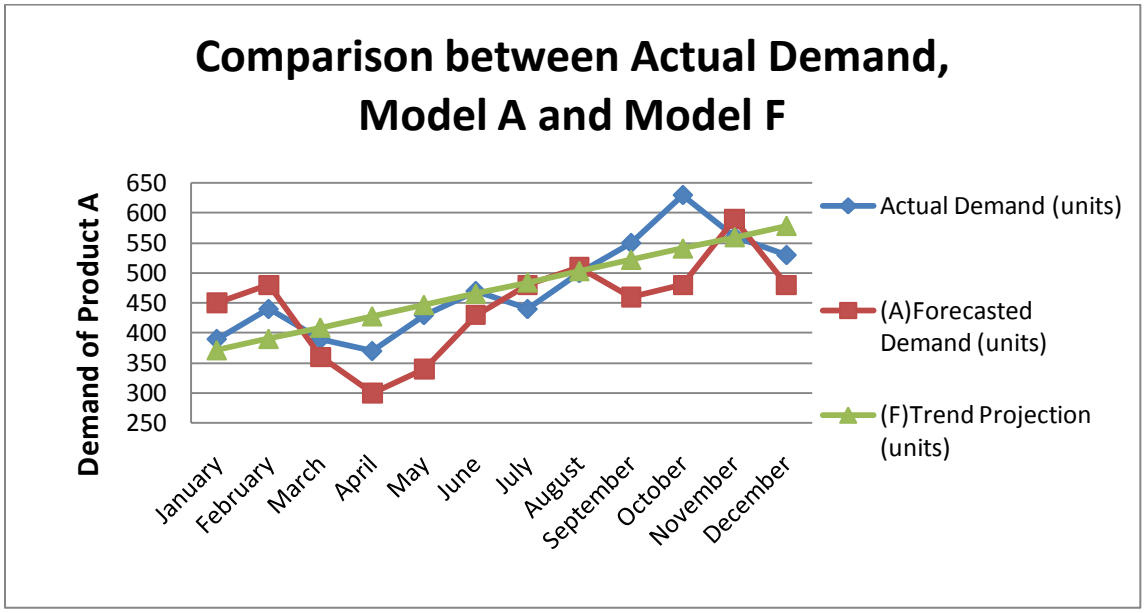


Figure 4.10: Comparison between the Actual Demand, Model A and Model F



4.3.3 Evaluation of the Forecasting Method

In order to measure the forecasting performance in providing accuracy information, there are four types of forecasting error measure including mean absolute deviation (MAD), mean squared error (MSE), mean absolute percentage error (MAPE) and tracking signal. The forecasting error indicates how the performance of the time series models using historical data. In this study, measuring forecast errors enhanced forecast accuracy and the most suitable forecasting method comes with smallest forecast error.

4.3.3.1 Examine the Accuracy of Various Forecasting Methods

1. Mean Absolute Deviation (MAD)

$$MAD = \frac{1}{n}\sum_{t=1}^{n}\left|A_t - F_t\right|$$

MAD can be described as the most popular and simplest measurement of forecasting accuracy. It refers to the average of the difference between the forecast and the actual demand. The smaller value of MAD, the more accurate the forecast performance.

2. Mean Absolute Percentage Error (MAPE)

$$MAPE = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

The second accuracy measure is MAPE or mean absolute percentage error. It is calculated by taking the absolute deviation and dividing it by the data to get the percent error.

3. Mean Squared Error (MSE)

$$MSE = \frac{1}{n}\sum_{t=1}^{n}(A_t - F_t)^2$$

The Mean Squared Error is the arithmetic mean of the sum of the squares of the prediction errors. This error measure is popular to be used. The smaller the MSE value, the more stable the model.

4. Tracking Signal

Tracking Signal = Σ (At-Ft)/MAD

Tracking Signal is computed to determine the larger deviation (whether in plus and minus) of forecast error in various model. Tracking signal is mathematically defined as the sum of the forecast errors divided by the mean absolute deviation. Whenever the movement of tracking signal satisfies the boundary between –4 and 4, the forecast result is in control and the model is working correctly.

In order to calculate the forecast error, forecasting software, POM-QM has been applied to measure the difference accuracy between various forecasting models. The software helped to calculate the forecast error quickly and easily.

POM-QM is software for production management and quantitative methods. The spreadsheet-type data editor makes data entry and editing relatively easy. Besides, whenever historical data is to be entered, there is a clear instruction given on the screen describing what is to be entered and when data is entered incorrectly a clear error message is displayed.

4.3.3.1 Forecast Error Measurement For The Forecasting Model Develop By Company J (Model A)

	Actual Demand	Time(x)	Error	|Error|	Error^2	|Pct Error|
January	390	450	-60	60	3600	.15
February	440	480	-40	40	1600	.09
March	390	360	30	30	900	.08
April	370	300	70	70	4900	.19
May	430	340	90	90	8100	.21
June	470	430	40	40	1600	.09
July	440	480	-40	40	1600	.09
August	500	510	-10	10	100	.02
September	550	460	90	90	8100	.16
October	630	480	150	150	22500	.24
November	560	590	-30	30	900	.05
December	530	480	50	50	2500	.09
TOTALS	5700		340	700	56400	1.47
AVERAGE	475		28.33	58.33	4700	.12
Next period forecast		597.27	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	75.1	

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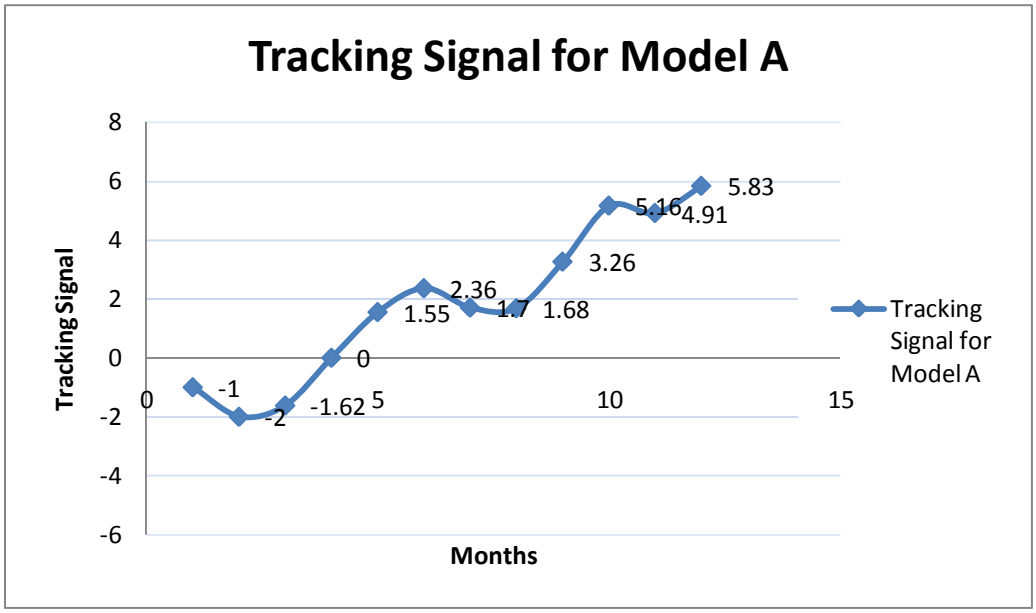
	Actual Demand	Forecast	Error	RSFE	|RSFE|	Cum Abs	Cum MAD	Track Signal
January	390	450	-60	-60	60	60	60	-1
February	440	480	-40	-100	40	100	50	-2
March	390	360	30	-70	30	130	43.33	-1.62
April	370	300	70	0	70	200	50	0
May	430	340	90	90	90	290	58	1.55
June	470	430	40	130	40	330	55	2.36
July	440	480	-40	90	40	370	52.86	1.7
August	500	510	-10	80	10	380	47.5	1.68
September	550	460	90	170	90	470	52.22	3.26
October	630	480	150	320	150	620	62	5.16
November	560	590	-30	290	30	650	59.09	4.91
December	530	480	50	340	50	700	58.33	5.83

Figure 4.11: Tracking Signal for Model A (Forecast demand by Company J)



4.3.3.2 Forecast Error Measurement For Simple Moving Average (Model B)

Moving Averages | 2

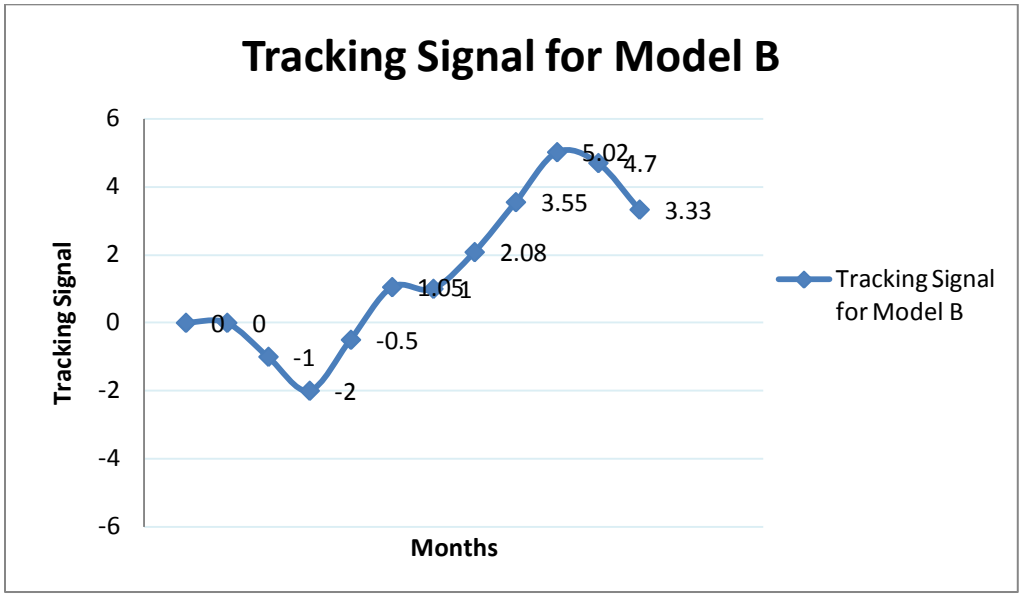
	Actual Demand	Forecast	Error	|Error|	Error^2	|Pct Error|
January	390					
February	440					
March	390	415	-25	25	625	.06
April	370	415	-45	45	2025	.12
May	430	380	50	50	2500	.12
June	470	400	70	70	4900	.15
July	440	450	-10	10	100	.02
August	500	455	45	45	2025	.09
September	550	470	80	80	6400	.15
October	630	525	105	105	11025	.17
November	560	590	-30	30	900	.05
December	530	595	-65	65	4225	.12
TOTALS	5700		175	525	34725	1.05
AVERAGE	475		17.5	52.5	3472.5	.11
Next period forecast		545	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	65.88	

Moving Averages | 2

(untit

	Actual Demand	Forecast	Error	RSFE	|RSFE|	Cum Abs	Cum MAD	Track Signal
January	390							
February	440							
March	390	415	-25	-25	25	25	25	-1
April	370	415	-45	-70	45	70	35	-2
May	430	380	50	-20	50	120	40	-.5
June	470	400	70	50	70	190	47.5	1.05
July	440	450	-10	40	10	200	40	1
August	500	455	45	85	45	245	40.83	2.08
September	550	470	80	165	80	325	46.43	3.55
October	630	525	105	270	105	430	53.75	5.02
November	560	590	-30	240	30	460	51.11	4.7
December	530	595	-65	175	65	525	52.5	3.33

Figure 4.12: Tracking Signal for Model B (Simple Moving Average)



4.3.3.3 Forecast Error Measurement For Weighted Moving Average (Model C)

Weighted Moving Averages | 2

	Demand(y)	Forecast	Error	|Error|	Error^2	|Pct Error|
January	390					
February	440					
March	390	420	-30	30	900	.08
April	370	410	-40	40	1600	.11
May	430	378	52	52	2704	.12
June	470	406	64	64	4096	.14
July	440	454	-14	14	196	.03
August	500	452	48	48	2304	.1
September	550	476	74	74	5476	.13
October	630	530	100	100	10000	.16
November	560	598	-38	38	1444	.07
December	530	588	-58	58	3364	.11
TOTALS	5700		158	518	32084	1.04
AVERAGE	475		15.8	51.8	3208.4	.1
Next period forecast		542	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	63.33	

Weighted Moving Averages | 2

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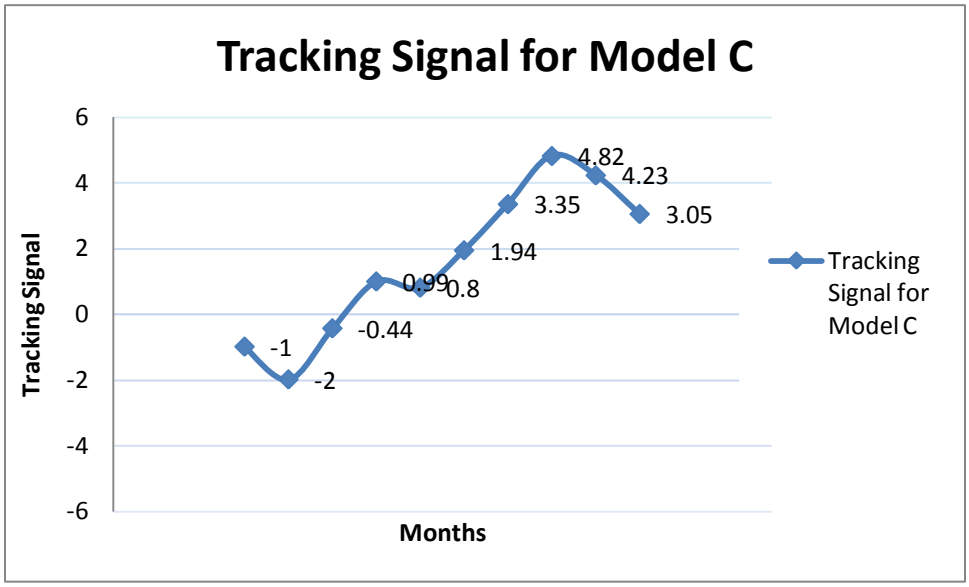
	Demand(y)	Forecast	Error	RSFE	|RSFE|	Cum Abs	Cum MAD	Track Signal
January	390							
February	440							
March	390	420	-30	-30	30	30	30	-1
April	370	410	-40	-70	40	70	35	-2
May	430	378	52	-18	52	122	40.67	-.44
June	470	406	64	46	64	186	46.5	.99
July	440	454	-14	32	14	200	40	.8
August	500	452	48	80	48	248	41.33	1.94
September	550	476	74	154	74	322	46	3.35
October	630	530	100	254	100	422	52.75	4.82
November	560	598	-38	216	38	460	51.11	4.23
December	530	588	-58	158	58	518	51.8	3.05

Figure 4.13: Tracking Signal for Model C (Weighted Moving Average)



4.3.3.4 Forecast Error Measurement For Exponential Smoothing (Model D)

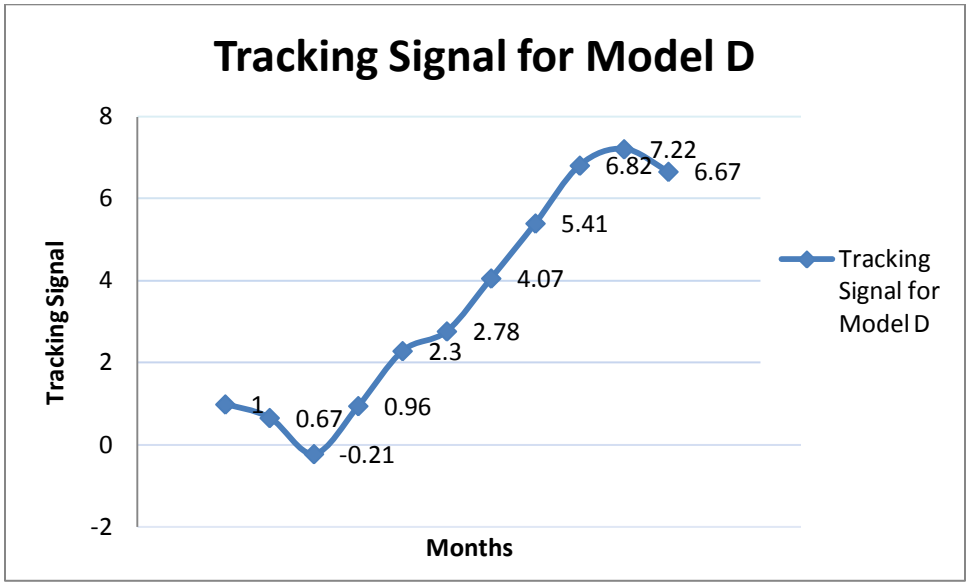
Exponential Smoothing .5

	Actual Demand	Forecast	Error	|Error|	Error^2	|Pct Error|
January	390					
February	440	390	50	50	2500	.11
March	390	415	-25	25	625	.06
April	370	402.5	-32.5	32.5	1056.25	.09
May	430	386.25	43.75	43.75	1914.06	.1
June	470	408.13	61.88	61.88	3828.52	.13
July	440	439.06	.94	.94	.88	.0
August	500	439.53	60.47	60.47	3656.47	.12
September	550	469.77	80.23	80.23	6437.56	.15
October	630	509.88	120.12	120.12	14428.14	.19
November	560	569.94	-9.94	9.94	98.83	.02
December	530	564.97	-34.97	34.97	1222.95	.07
TOTALS	5700		314.97	519.79	35768.65	1.04
AVERAGE	475		28.63	47.25	3251.7	.09
Next period forecast		547.49	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	63.04	

Exponential Smoothing .5

	Actual Demand	Forecast	Error	RSFE	|RSFE|	Cum Abs	Cum MAD	Track Signal
January	390							
February	440	390	50	50	50	50	50	1
March	390	415	-25	25	25	75	37.5	.67
April	370	402.5	-32.5	-7.5	32.5	107.5	35.83	-.21
May	430	386.25	43.75	36.25	43.75	151.25	37.81	.96
June	470	408.13	61.88	98.13	61.88	213.13	42.63	2.3
July	440	439.06	.94	99.06	.94	214.06	35.68	2.78
August	500	439.53	60.47	159.53	60.47	274.53	39.22	4.07
September	550	469.77	80.23	239.77	80.23	354.77	44.35	5.41
October	630	509.88	120.12	359.88	120.12	474.88	52.76	6.82
November	560	569.94	-9.94	349.94	9.94	484.82	48.48	7.22
December	530	564.97	-34.97	314.97	34.97	519.79	47.25	6.67

Figure 4.14: Tracking Signal for Model D (Exponential Smoothing)



4.3.3.5 Forecast error measurement for Trend Adjusted Exponential Smoothing (Model E)

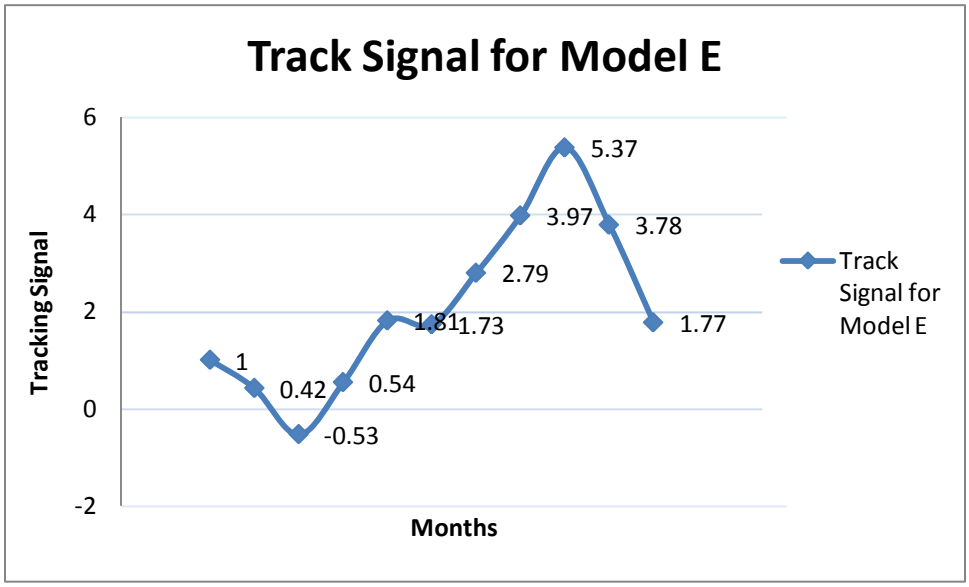
Exponential Smoothing with trend | .5

	Actual Demand	Smoothed Frcst, Ft	Smoothed Trend, Tt	Frcst Inc Trend,FITt	Error	|Error|	Error^2	|Pct Error|
January	390							
February	440	390	0	390	50	50	2500	.11
March	390	415	7.5	422.5	-32.5	32.5	1056.25	.08
April	370	406.25	2.63	408.88	-38.88	38.88	1511.27	.11
May	430	389.44	-3.21	386.23	43.77	43.77	1915.7	.1
June	470	408.12	3.36	411.47	58.53	58.53	3425.21	.12
July	440	440.74	12.14	452.88	-12.88	12.88	165.77	.03
August	500	446.44	10.21	456.64	43.36	43.36	1879.73	.09
September	550	478.32	16.71	495.03	54.97	54.97	3021.48	.1
October	630	522.52	24.96	547.47	82.53	82.53	6811.01	.13
November	560	588.74	37.33	626.07	-66.07	66.07	4365.25	.12
December	530	593.04	27.42	620.46	-90.46	90.46	8182.83	.17
TOTALS	5700				92.37	573.93	34834.5	1.16
AVERAGE	475				8.4	52.18	3166.77	.11
Next period forecast		575.23	13.86	589.08	(Bias)	(MAD)	(MSE)	(MAPE)
						Std err	62.21	

Exponential Smoothing with trend | .5

	Actual Demand	Forecast	Error	RSFE	|RSFE|	Cum Abs	Cum MAD	Track Signal
January	390							
February	440	390	50	50	50	50	50	1
March	390	422.5	-32.5	17.5	32.5	82.5	41.25	.42
April	370	408.88	-38.88	-21.38	38.88	121.38	40.46	-.53
May	430	386.23	43.77	22.39	43.77	165.14	41.29	.54
June	470	411.47	58.53	80.92	58.53	223.67	44.73	1.81
July	440	452.88	-12.88	68.04	12.88	236.54	39.42	1.73
August	500	456.64	43.36	111.4	43.36	279.9	39.99	2.79
September	550	495.03	54.97	166.37	54.97	334.87	41.86	3.97
October	630	547.47	82.53	248.9	82.53	417.4	46.38	5.37
November	560	626.07	-66.07	182.83	66.07	483.47	48.35	3.78
December	530	620.46	-90.46	92.37	90.46	573.93	52.18	1.77

Figure 4.15: Tracking Signal for Model E (Trend Adjusted Exponential Smoothing)



4.3.3.6 Forecast Error Measurement For Trend Projection (Model F)

Trend Analysis (regress over time)

There are more results available in additional windows. These may be opened by

(untitled) Solution

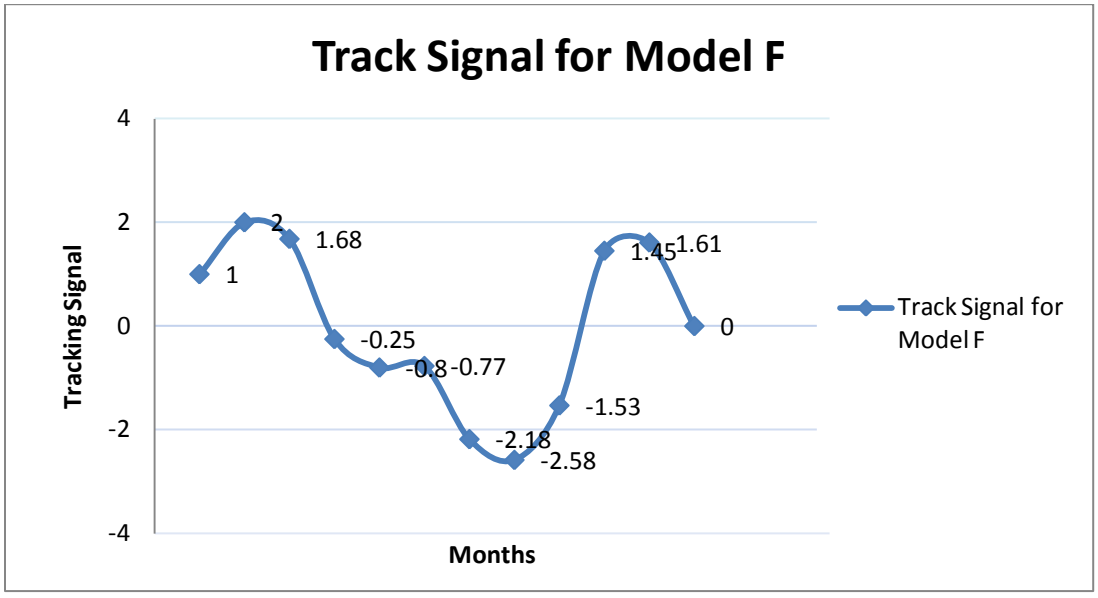
	Actual Demand	Time(x)	x^2	x * y	Forecast	Error	|Error|	Error^2	|Pct Error|
January	390	1	1	390	371.54	18.46	18.46	340.83	.05
February	440	2	4	880	390.35	49.65	49.65	2465.16	.11
March	390	3	9	1170	409.16	-19.16	19.16	367.14	.05
April	370	4	16	1480	427.97	-57.97	57.97	3360.76	.16
May	430	5	25	2150	446.78	-16.78	16.78	281.68	.04
June	470	6	36	2820	465.59	4.41	4.41	19.41	.01
July	440	7	49	3080	484.41	-44.41	44.41	1971.86	.1
August	500	8	64	4000	503.22	-3.22	3.22	10.35	.01
September	550	9	81	4950	522.03	27.97	27.97	782.44	.05
October	630	10	100	6300	540.84	89.16	89.16	7949.65	.14
November	560	11	121	6160	559.65	.35	.35	.12	0
December	530	12	144	6360	578.46	-48.46	48.46	2348.52	.09
TOTALS	5700	78	650	39740		0	380	19897.9	.81
AVERAGE	475	6.5				0	31.67	1658.16	.07
Next period forecast					597.27	(Bias)	(MAD)	(MSE)	(MAPE)
Intercept	352.73						Std err	44.61	
Slope	18.81								

Trend Analysis (regress over time) | There are more results available in additional windows. These may

(until

	Actual Demand	Forecast	Error	RSFE	|RSFE|	Cum Abs	Cum MAD	Track Signal
January	390	371.54	18.46	18.46	18.46	18.46	18.46	1
February	440	390.35	49.65	68.11	49.65	68.11	34.06	2
March	390	409.16	-19.16	48.95	19.16	87.27	29.09	1.68
April	370	427.97	-57.97	-9.02	57.97	145.24	36.31	-.25
May	430	446.78	-16.78	-25.8	16.78	162.03	32.41	-.8
June	470	465.59	4.41	-21.4	4.41	166.43	27.74	-.77
July	440	484.41	-44.41	-65.8	44.41	210.84	30.12	-2.18
August	500	503.22	-3.22	-69.02	3.22	214.06	26.76	-2.58
September	550	522.03	27.97	-41.05	27.97	242.03	26.89	-1.53
October	630	540.84	89.16	48.11	89.16	331.19	33.12	1.45
November	560	559.65	.35	48.46	.35	331.54	30.14	1.61
December	530	578.46	-48.46	0	48.46	380	31.67	0

Figure 4.16: Tracking Signal for Model F (Trend Projection)



4.3.4 Comparison of Forecast Error Among Forecasting Method

In order to determine how well the various forecasting techniques to create the time series data, a comparison table of forecast error is developed together with the forecast error measurement. By comparing the methods that has the best accuracy for the past data, better forecasting technique for future demand is likely to be implemented by Company J.

Forecast Error / Forecasting Model		Mean Absolute Deviation (MAD)	Mean Squared Error (MSE)	Mean Absolute Percentage Error (MAPE)	Tracking Signal
Model A	MRP system by the Company J	58.33	4700	0.12	±6
Model B	Simple Moving Average	52.5	3472.5	0.11	±5
Model C	Weighted Moving Average	51.8	3208.4	0.10	±5
Model D	Exponential Smoothing	47.25	3251.7	0.09	±8
Model E	Trend Adjusted Exponential Smoothing	52.18	3166.77	0.11	±6
Model F	Trend Projection	31.67	1658.16	0.07	±3

From the table above, we can see that the MRP system (Model A) in the company J that developed the forecast demand produced the Mean Absolute Deviation (MAD) of 58.33, Mean Squared Error (MSE) of 4700 and Mean Absolute Percentage Error (MAPE) of 0.12. The forecast errors are normally distributed which results in the following relationship between MAD and the standard deviation of the error distribution. This enable we to understand the statistical control limits for the tracking signal showed ±6 standard deviation in the forecast model by Company J. The model A has the highest value of the MAD, MSE

and MAPE compared with others model. This indicate that the forecast result is inaccurate compared with others model based on the forecast error measurement.

Then, Simple Moving Average (Model B), Weighted Moving Average (Model C) and Trend Adjusted Exponential Smoothing (Model D) have a higher value in term of MAD, MSE MAPE than Exponential Smoothing (Model D) and Trend Projection (Model F). Besides, the deviations limit in these three methods is within ± 5 to ± 6 standard deviation. These three methods produced a large forecast error and are not suitable to apply in manufacturing company. Simple Moving Average cannot predict the future demand very well as unable to produce accurate forecasts if the data incurred has cyclical or seasonal variations. It does not lever trend very well and makes the forecasts lag behind the underlying trend.

In Weighted Moving Average calculation, it unable generates accurate forecasts if the data has seasonal or cyclical variations. In practice, actual past data values have to be multiplied by some weights and it caused calculations more difficult. Trend Adjusted Exponential Smoothing method create the forecasts are sensitive to the specification of the smoothing constant. It cannot make accurate forecasts if the past data has cyclical or seasonal variations as well as it failed to handle trend very well. The discrepancy between the actual demand and the forecast demand has the tendency to cause the company to waste money in managing their inventory and production system.

Exponential Smoothing (Model D) has a lower value in MAD, MSE and MAPE when compared with Model A, B, C. It computes the data as a whole and does not show cut-off points as in the case with moving averages methods. However, the tracking signal shows the highest control limit as ± 8 standard deviation in monitoring the forecast error. Tracking signal notified if there is a tendency for actual value to be higher or lower relatively. In practice, within 3 standard deviations, the tracking signal that is in the range of 3.75 is considered to be good enough. If forecast value is consistently higher or lower than the actual demand value, then there implies a forecast bias and Tracking Signal shows a large deviation. So in essence, exponential smoothing is not a suitable tool to forecast the actual demand for the product A as the deviation of forecast error beyond the normal distribution. The exponential smoothing method has the tendency to create forecasts that lag behind the actual trend.

However, there are some differences between exponential smoothing and moving average. In practice, exponential smoothing do not require large amount of past data and new forecast are created easily and updating only depends on previous data point. By implementing exponential smoothing, the unusual data effect able to fades uniformly. Meanwhile, moving average method uses the average of the most recent actual data values in the time series as the forecast for the next period. In practice, this method can generate a good forecast in term of short run, but it should not be used to predict into the long term future.

As shown in the table above, Trend Projection (Model F) yield the least forecast error than the Model A, B, C, D and E. There is an obvious difference between the value of MAD, MSE and MAPE compared with the previous five models. When monitoring the forecast accuracy, many company focus mostly on the MAPE to choose the best forecasting method. The MAPE of Model F shows 0.07 which is the lowest value among the other model and since it is within 0.1 percentage errors, the forecast result is relatively accurate and useful for the production demand in Company J.

In additional, as the distribution of the tracking signal is compared to statistical control limits to assess the forecast error. The Model F has the normal distribution of ± 3, as long as the tracking signal is within standard limits, the forecast demand is in control. In general, control limits of ±2 to ±4 are most frequently used. Hence, the result of Model F shows that the forecast is in control. As Model F is exceeding in all forecast error test, it is by far superior to the other models. With the help of POM software, it indicates that Model F is far better than other model and should be implemented by the purchasing department in Company J.

In conclusion, Trend Projection was suggested as the most suitable forecasting method to be adopted in Company J. For short term forecast, trend projection appears to reflect closely the actual past data and would be the most suitable forecast model for this study.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter will elaborate about the findings on the data analysis in various forecasting methods to determine the most suitable forecasting method. Besides, the forecast error analysis will be discussed to compare the accuracy of the forecasting methods. Then, there are some recommendations and suggestions provided in this chapter as well to improve the performance of the forecasting in product demand.

5.2 RECAPITULATIONS OF THE RESEARCH

Forecasting plays a critical role in every business especially in manufacturing industry. Most of the operations decisions in manufacturing industry are based on some kind of forecast for future demand. On top of that, manufacturing company pay highly attention towards demand forecasting process and this study has devoted attention to this particular issue.

In a manufacturing environment, every company must clearly understand the reason of forecasts. Planners in a manufacturing company often must forecast the amount of inventory and supplies needed to meet the customer demands. As customer agrees some delivery lead times, the manufacturing company need more time earlier to purchase components and raw materials to manufacture and deliver the finished products. In other

words, accurate forecast is essential for production planner to plan effectively to satisfy the customers demand.

This research involved three research objectives. First, evaluate the demand forecasting method used by the manufacturing company. Second, analyses the sale data of the company using several forecasting method. The third objective is to propose the most suitable forecasting method to the manufacturing company.

The research were conducted by having face-to-face interview with the planner in the Company J and the data were collected regarding the forecasting method adopted by them in production planning for Product A. MRP system were used by the planner to develop the forecast demand for the production planning purpose. The planner loaded the previous customer data into the MRP system to generate the forecast demand for future use.

Then, the data provided by the planner including a set of consecutive twelve months actual demand for Product A that were analyses in this study. The data set provided was the previous customer demand in 2012 and 2011. Time series forecasting methods analysis were applied on the past data for selecting the best method that can be used to forecast of future events. The time series forecasting method involved simple moving average, weighted moving average, exponential smoothing, trend adjusted exponential smoothing and trend projection were applied to generate the forecast for Product A. After that, forecast error analysis were used to assess the performance of the forecast result and select the best forecasting method to be applied in production planning.

5.3 DISCUSSION ON THE APPROACHES METHODS

The simple moving average, weighted moving average, exponential smoothing, trend adjusted smoothing and trend projection model were applied to develop the forecast demand for Product A. POM software were applied to develop the forecast result for the modes above. The forecast result of each model was compared to the actual demand.

In order to measure the forecasting performance in providing accuracy information, forecasting error analysis including mean absolute deviation (MAD), mean squared error (MSE), mean absolute percentage error (MAPE) and tracking signal were applied on various model. The forecasting error aimed to compare and monitor the performance among the time series models using historical data. In this study, measuring forecast errors enhanced forecast accuracy and the most suitable forecasting method comes with smallest forecast error.

The most suitable forecasting method for the demand forecasting in Company J is trend projection. The forecast error in this method appears to the lowest compared to the other model in term of MAD, MSE and MAPE. Besides, tracking signal measure whether the forecasting model applied is suitable for a certain product by comparing the results of previous forecasts with the actual demand and monitor whether the forecast error has exceeded a control limit value too high or low. The tracking signal in trend projection is within the limit of ± 4 while the other models go beyond acceptable limits of ±4. As long as the tracking signals within the boundaries ± 4, the forecast result is in control.

The forecast result in trend projection appears to reflect closely the actual demand and it shows good fit in the trend line to the actual data. Hence, it is a good forecasting model for this study. When create forecast by applying trend projection method, consistent relationship between the variables is assumed. Trend projection performs better by providing confidence intervals and statistical tests for the actual forecasts which some quantitative techniques lack.

It is easy to use and is commonly used among the other business units. It is a very suitable method to be used in forecasting short term range product in manufacturing industry. Trend projection help planner make sense of the production planning and improve their planning with better demand forecasting.

However, as this research was specified to the demand forecasting in particular production planning department, the result of the study is not suitable for other situation and firm to apply. This is because forecasting can be used for many purpose and outcomes may be difference according to the industry condition.

As a result, company should gather the appropriate data, process and model to create accurate forecast to improve the performance of the firm production planning. Moreover, cross functional department should have more discussion and collaboration in order to understand the product demand and better forecast the demand to satisfy customer requirement.

5.4 RECOMMENDATIONS

This study proposed trend projection should be implemented by the manufacturing industry as the most suitable forecasting method. It is generally used for identifying trends and the trend direction. It would be interesting to review and analyze the forecast result of this method to see if the applications improve the product demand in future. This method is generally used to include more variables to predict demand more accurately and forecast the impact of seasonal changes. With the common availability of past data in every field and the forecasting software to process it, applications for trend projection analysis can applied for many purpose. A trend projection analysis can be simulated, assessed, updated and developed when necessary to improve the production planning process.

Forecasts software able to provide a basic foundation for organization's planning by offers a number of capabilities that enable users to quickly develop reliable forecasts using time-series data. A good software package and analytical tool sets offer the advanced techniques for user without the drawbacks of traditional methods. Moreover, it enables user to use advanced statistical methods in developing forecasts rather than spreadsheet programs. User at the beginner stage to forecasting can generate sophisticated forecasts that take into account multiple variables. For advanced user, the forecast software provides the capability to validate their models. Forecast software is a very convenient tool for the forecaster to obtain the information needed at the faster time as the software give instruction on every step of the way. For example, the forecast software includes Forecast Pro, Sage 50 Forecasting, Statgraphics Centurion and ForecastX Wizard.

In order to enhance the forecasting accuracy, forecast combination known as ensemble forecasting has been proposed by many academic papers in forecasting journals and articles. It has been suggested that forecast accuracy can be improved by integrating multiple forecasts technique and reduce the variability of the combined forecast. Besides, simple combination methods seem to function reasonably well compared to complicated combinations. Forecast combination can be helpful when forecasters are uncertain about the situation, confuse about the best method and when they want to avoid large errors.

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APPENDIX I

Dear Sir/ Madam,

First of all, thank you for participating in this interview. We whole heartedly would like to invite you to contribute in this interview and taking you in advance appreciation for your kind involvement. The present study is to analyze the forecasting method used in manufacturing industry. Kindly complete the attached questionnaire based on your honest opinion and experience. Your response will be treated with highest confidentially and only will be used for the purpose of the academic research.

This research is purely an academic study undertaken to fulfill the partial requirement for completed our bachelor in Faculty of Technology at University Malaysia Pahang.

Lastly, we would like to thank you for your high cooperation in this interview. Your high cooperation and participation is highly appreciated. Should you have any further question, please do not hesitate to contact us.

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Interview Questions

1. What is the current forecasting technique adopted by your company?
2. How accurate was the forecasting tool?
3. How effective was the forecasting technique in detecting significant shift in demand?
4. Who is responsible for the sale forecast for the product A?
5. What variable is involved in selecting the forecasting method?
6. What data will be considered and gathered when develop a demand forecast?
7. What is the specific time horizon for the demand forecast of product A been made each time?
8. How long time will be needed to gather and analyze data in order to prepare the forecast?
9. What steps have been used in forecast for product A?
10. What difficulty will be faced when forecast the demand for product A?
11. Is the demand forecast result accurate compared to the actual demand for the product A using the current forecasting technique?
12. Is there any factor or alternative to be considered to ensure that the demand forecast for product A is most accurate and unbiased?
13. Is there any measurement tool used to evaluate the demand forecast performance?
14. How much is the current demand forecasting system cost in order to secure and use of demand information?

Answers

1) There are a few forecasting techniques using in my company depends on which forecasting model set in system. Commonly used is the normal MRP system.

2) The accuracy is based on the setting as well, yet in practice the forecast always appear wrongly.

3) So far forecast model play a significant role in the flexibility in demand changing.

4) Business Department is working with Purchasing Department

5) There are few of it, e.g. Lot Size, Planning Cycle, Safety Stock, etc

6) Lead time, cycle time, production availability, etc

7) Depends on the product

8) Depends on customer based, some is weekly, some is monthly

9) Problem definition, gathering information, preliminary analysis, determines the forecasting technique, creates the forecast and established performances for the forecast.

10) There are many factors need to consider such as disaster and competitors

11) Not really accurate.

12) No

13) No

14) This is the under engineering department control which we do not have the answer.

DISCLAIMER

All information provided by the participants in this research will be treated as private and confidential and will be handled with due care.