The Fundamental on Demand Forecasting in Inventory Management
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Abstract: Several past studies or some inventory management text book have shown that the accuracy of the demand forecast significantly affects safety stock and inventory levels, inventory holding costs, and customer service levels. Currently, the Closed-circuit Television (CCTV) distributor Company is facing the problem meeting the required inventory level for some of the product and the problem might be due to inaccurate demand forecast. The objectives of this paper are to implement and compare the performance of individual forecasting techniques and combination forecasting technique in demand forecast for inventory management. The study will be conduct using case study method. The demand data for one of the series product will be collect. Data analysis will be held using three individual forecasting method and two combination forecasting method.

Key words: Demand forecasting, Combination Forecasting, Forecast Measures of Accuracy

INTRODUCTION

Demand forecasting includes the prediction, projection or estimation of expected demand of the products over a specified future time period. The demand products frequently changes in the marketplace due to the seasonality factor, trend factor, and economic factor. As soon as the main selling season passes, the extra inventories of the product are devalued greatly. Therefore, demand planning is considered the first step of a supply chain planning process, which provides a continuous link to manage the inventory position and the product demand.

Research Background:
The important of forecasting also mirror in the industry. Most of the small and medium enterprise (SME) companies in Malaysia determine product demand forecast using judgmental forecast or simple quantitative forecast method such as simple moving average and simple exponential smoothing method.

Several past studies or some inventory management text book have shown that the accuracy of the demand forecast significantly affects safety stock and inventory levels, inventory holding costs, and customer service levels. According to Chan et al. (1999), unnecessary high stocks may result from high demand forecasting errors. Hence, having a forecasting technique with a smaller forecast error will help in this problem. However, just having a single individual forecasting for inventory decision is not enough. In this case, combination of forecast will be useful. The combined forecast might improve the accuracy of the forecast and reduce the forecast error of individual forecast.

Background of the Case Study:
The Closed-circuit Television (CCTV) distributor company has numerous products under two brands. The product sell in this company include camera for CCTV use, digital video recorder, wireless camera, monitor, controller, lens and others product.

Problem Statement:
Currently, the CCTV Company is facing the problem meeting the required inventory level for some of the product. The role of demand forecasting in inventory management can be explained clearly by Korpcla and Tuominenb (1996). According to Korpcla and Tuominenb (1996), forecasting the demand for products both in the immediate future and over longer time periods is one of the most crucial issues in inventory management. The aim of demand forecasting is to estimate the amount of product and accompanying service that customers will require at some point in the future. Based on the forecasts, the management can decide how much of each
product must be placed or stored in the market. Thus, the inventory problem in the CCTV distributor company might be due to inaccurate demand forecast. In this study, the objective is to find the demand forecast for inventory management and to find the best forecast to anticipate the right demand in order to solve the inventory problem.

**Objective and Research Scope:**

The first objective of this paper is to implement individual forecasting techniques and combination forecasting technique in demand forecast for inventory management. The second objective is to compare the performances between combined forecasts and individual forecasts.

This study will use data collected from one of the main distributors for the CCTV product in Malaysia. The data include the order unit and the selling amount of the product. There are two carrier CCTV brand under the case study company. Due to the limitation of the time, the study will focus on one of the series of product under the carrier brand of the company only.

**Literature Review:**

**Demand Forecasting:**

Inventory control has become an important component in supply chain management. One of the critical success factors in inventory management is accurate demand forecasting. Many researchers had use different approaches’ to generate forecast of product demand for inventory control purpose. According to Kerkkanen et al. (2009), demand forecasting is commonly applied in companies that operate in consumer markets. When demand patterns are relatively smooth and continuous, demand forecasts based on historical demand are usually quite accurate. Success stories about demand forecasting typically report lower inventory levels and improved customer service.

Phelan and McGarraghy (2006) apply the simple exponential smoothing method in a telecommunications industry supply chain producing Digital Subscriber Line (DSL) concentrators, where component manufacture had been outsourced. The result shows that the simple exponential smoothing method which does not take any trends or seasonality into account consistently provided more accurate forecasts than current forecast method used by the company which forecasts based largely on managerial judgment. This is supported by the Blecher (2004).

However, Willemain et al. (2004) share the opposite opinion regarding the performance of the exponential smoothing. Willemain et al. (2004) using various forecasting model to forecast the demand for inventory management system and exponential smoothing is one of the method used in this study. In this study, the result showed that exponential smoothing did not provide an overall improvement when the task was to forecast the entire distribution of lead time demand. This is supported by Teunter and Duncan (2006) and Chandra and Grabis (2005)

Tiacci and Saetta (2009) study a real case of a company that markets tinned food for the hotel, restaurant and catering segment. The forecasting method that used in this study is the three-month moving average method. The result found that the accuracy of the moving average method is higher in term of MAD and MAPE. This is supported by the Blecher (2004). However, Chandra and Grabis (2005) had opposite opinion. In the study done by Chandra and Grabis (2005) regarding the impact of the forecasting method selection on inventory performance, the result show that the application of, simple moving average with averaging over five previous observations does not lead to improved inventory performance for the downstream unit measured by the average inventory size at the fixed service level compared to other forecasting methods considered.

**Combining Forecast:**

According to Armstrong (2001), combining forecasts can be refer as composite forecasts, refers to the averaging of independent forecasts. Combining forecast also known as hybrid method (Arinze et al., 1997). According to Armstrong (2006), combining forecasts calls for developing forecasts from different methods or data, and then averaging the forecasts from these methods, typically using a simple average. He had summarizes what has been learned over the past quarter century about the accuracy of forecasting method and concluded that over the past quarter century, evidence from comparative studies has led to seven well-supported forecasting methods. One of these methods applies to all types of data: combined forecasts with an estimated 12% error reduction.

Equal weights method can be refer as the simple averaging combination method or unweighted mean. This method yields the average value of forecasting of the individual forecasts that involve as result. Armstrong (2001) review that equal weighting is appealing because it is simple and easy to describe. In his review, equal weight method is recommend when there does not have strong evidence to support unequal weights forecast and when the situation is uncertain.
Makridakis and Hibon (2000) summarized results for the latest M-Competitions, M3-Competition. This paper compares results with those of the previous two M-Competitions as well as with those of other major empirical studies. They found that the simple averaging combination method is more accurate than the individual method being combined for practically all forecasting horizons. In the study, they reported a 4.3% error reduction for combination forecast method in the large scale M3-Competition with its 3,003 series. The idea of improving forecast accuracy by equal weights combination method is supported by Golinelli and Parigi (2008) and Taylor et al. (2006).

Many of the above-mentioned studies give support to the idea that forecast combination can significantly improve forecasting accuracy especially equal weights combination method. However, some researchers have suggested that combined forecast do not always improve forecast accuracy under all circumstances. Koning et al. (2005) examined the primary findings of the M3 competition and found the conclusion of the M3-competition study stated that in some cases, the accuracy of the combination of methods (equal weights) was significantly better than the individual techniques; in other cases, this was not true. Because only one combination of methods was examined and because these results are conflicting, they believe that the M3 conclusion about the combination of methods being significantly superior was not proved. This is also supported by Hibon and Evgeniou (2005) with results from their study that indicate the advantage of combining forecasts with equal weights method is not that the best possible combinations perform better than the best possible individual forecasts.

**Forecast Measures of Accuracy:**

In the past, many measures of forecast accuracy have been proposed and several studies have made recommendations about what should be used when comparing the accuracy of forecast methods. Many textbooks had recommended the use of the mean absolute percentage error (MAPE) and the root mean square error (RMSE). According to Lam et al. (2001), mean absolute percentage error (MAPE) has become popular as a performance measure in forecasting. One of the major reasons for its popularity is that it is easy to interpret and understand. As stated in the study of comparing the accuracy of six univariate methods for short-term electricity demand forecasting for lead times up to a day ahead by Taylor et al. (2006), they calculated the root mean squared percentage error (RMSE) and root mean squared error (RMSE). They found that the relative performances of the methods for these measures were very similar to those for the MAPE.

The researcher often used the MAPE and RMSE as their primary measure in their research. The study that using MAPE are Makridakis and Hibon (2000), Sanders and Ritzman (2004) and Altay et al. (2007). The study that using RMSE are Chan et al. (1999), Golinelli and Parigi (2008) and Kapetanios et al. (2008). The study that using both MAPE and RMSE are Gardner et al. (2001), Taylor et al. (2006) and Xiao et al. (2008).

In conclusion, as shown by the past studies, MAPE is one of the popular forecasting measurement tools. Thus, there is no doubt that it will be used in this study as the method for measurement of accuracy. Although the popularity for RMSE is not as popular as compared to the MAPE. However, it often use in conjunction with the MAPE is several studies and the performance was quite encourage. Hence, it will be used as method for measurement of accuracy in this study as well.

**Methodology:**

Research methodology plays an important role in the research. This chapter will identifies and describes the appropriate research methodology to investigate the research problem and achieve the research objective being advanced in this study. It provides the overview of the research design as well as the data collection method and the data analysis method.

**Research design:**

In this study, the case study method will be used as research method. According to Yin (2003), case study research method can be define as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

As define by Yin (2003), case study can be carried out using single case study or multiple case studies. Single cases may be used to confirm or challenge a theory, or to represent a unique or extreme case. Single-case studies are also ideal for revelatory cases where an observer may have access to a phenomenon that was previously inaccessible. In this study, one of the objectives is to confirm the theory that the combination forecasting method is better than the individual forecasting method. Thus, single case study is suitable in this study.
Data Collection:

In this study, documentation sources will be used. According to Yin (2003), documents could be letters, memoranda, agendas, study reports, or any items that could add to the data base. In this study, secondary data relevant to the forecasting will be taken from the CCTV distributor company. Data taken will be past data kept by the company. The data that will be involved in this study is the monthly order unit and monthly sold out unit for the sample product.

Data Analysis:

Data analysis consists of examining, categorizing, tabulating, testing or otherwise combining both the quantitative and qualitative evidence to address the initial propositions of a study (Yin, 2003). In this study, the data analysis will be carried out using three individual forecasting method and two combination forecasting method. The forecasting result will be generating using Forecast X Software. The forecasting result will be evaluate using two forecasting measurement.

The forecasting methods:

The first forecasting method that will be used in this study is the moving average method. The second forecasting method that will be used in this study is the Holt-Winters exponential smoothing method. The third forecasting method that will be used is the simple linear regression method. The fourth and the fifth method will be the combination forecasting method using different method in determined the weight for the forecast. Instead of choosing the best model from among the forecasting method, a more reasoned approach is to combined the forecasts in order to obtained a forecast that is more accurate than any if the separate predictions. The detail of the formula for the furcating method will be shown below;

According to Frechtling (2002), the general equation for the single moving average is:

$$F_t = \frac{A_{t+1} - A_{t-2} - A_{t-n}}{n}$$  \hspace{1cm} (3.1)

According to Wilson and Keating (2007), the four equations necessary for Holt-Winters exponential smoothing method are as follow:

$$F_t = \frac{aX_t}{S_{t-p}} + (1-a)(F_{t-1} + T_{t-1})$$  \hspace{1cm} (3.2)

$$S_t = \frac{\beta X_t}{F_t} + (1-\beta)S_{t-p}$$  \hspace{1cm} (3.3)

$$T_t = \gamma(F_t - F_{t-1}) + (1-\gamma)T_{t-1}$$  \hspace{1cm} (3.4)

$$W_{t-m} = (\overline{F_t} + mT_t)S_{t-m-p}$$  \hspace{1cm} (3.5)

According to Frechtling (2002), the formula for the simple linear regression method is as follow:

$$Y_t = a + bX_t$$  \hspace{1cm} (3.6)

According to Frechtling (2002), the formula for computing the intercept, a, and the slope coefficient, b:

$$b = \frac{n \sum XY - (\sum X)(\sum Y)}{n \sum X^2 - (\sum X)^2}$$  \hspace{1cm} (3.7)

$$a = \overline{Y} - b\overline{X}$$  \hspace{1cm} (3.8)

According to Wilson and Keating (2007), the general formula for combination forecast method is as follow:

combined forecast = $w_1 F_1 + w_2 F_2 + \cdots + w_n F_n$  \hspace{1cm} (3.9)
According to Wilson and Keating (2007), the weights for combination method using equal weights can be calculated using the formula below:

\[ w = \frac{1}{n} \]  

(3.10)

The fifth method is the combination method using regression analysis to determine the weights. In order to apply this method and to determine the best value for the weights of each method involves, a two step regression process is used. First, a standard multiple regressions of the actual values on the value predicted from the individual forecasting method. According to Wilson and Keating (2007), the formula can be express as this:

\[ A = a + w_i(R_i) + w_j(R_j) \]  

(3.11)

The value of the intercept (a) should be zero if there is no bias in the combined forecast. Assuming that \(a=0\), a second regression will take part forcing the regression through the origin. The result of regressing the actual values on the two forecast series, without an intercept, yields the desired result to determine the best weights to be used in combining the forecast.

According to Wilson and Keating (2007), the formula for MAPE is as below:

\[ \text{MAPE} = \frac{\sum |A_i - F_i| / A_i}{n} \]  

(3.12)

According to Wilson and Keating (2007), the formula for the RMSE is as below:

\[ \text{RMSE} = \sqrt{\frac{\sum (A_i - F_i)^2}{n}} \]  

(3.13)

Accuracy measurement:

In order to identify the model that generally works the best, the study need some way to evaluate the accuracy of forecasting methods over a number of periods. Several methods have been devised to summarize the error generated by a particular forecasting method. In this study, two accuracy measurements will be used. The first accuracy measurement is the mean absolute percentage error (MAPE). The second accuracy measurement will be used is the root-mean square error (RMSE).

ForecastX software:

In order to carry out the forecasting calculation job, The ForecastX software will be used. It is software that well trusted by the industry as well as the academic industry. Hence, it is the suitable software to be used in this study. Thousands of companies of all sizes use the ForecastX software successfully today. Besides in the industry, the ForecastX software also had well known reputation in the academic industry. They had established education partner relationship with many of the university.

In order to provide a clearly picture about the operation of the Forecast X software in forecasting, the general operation steps and operation flow chart is provided in below.

Step 1: Enter the data into the excel software and start ForecastX.
Step 2: In the data capture dialog box identify the data that want to used and specify the data contain dates as well as the descriptive label
Step 3: If a data transformation is necessary, select the transform button in the forecast method tab.
On the data transformation screen, use the data series to display drop-down menu to select the data that need to analyze.
Step 4: If data adjustment is needed, select the adjust button in the forecast method tab. Next, use the data series to display drop-down menu to select the data that need to analyze. In the start row and end row box, select the range in the data set to adjust. Next, specify the adjust value and percentage.
Step 5: In the forecast method tab, select the forecasting technique in the method selection dialog box.
Step 6: In the statistics tab, select the statistic that desired
Step 7: In the report tab, select the report type.
Step 8: Select finish and the report will appear
Conclusions:

In summary, significant gains have been made in forecasting for inventory management. Advances have occurred in the development of methods based on combining forecasts. We have also occurred for methods based on statistical data, such as extrapolation and rule-based forecasting methods. Most recently, gains have come from the integration of statistical and judgmental forecasts.

Demand forecasting allows retailers to make better decisions about which prices to adjust and when, which products to promote, and what promotional tactics to deploy, in order to achieve objectives. The benefits are significantly more profound and productive than a simple sales forecast. The best informed decisions will help us increase profits, sales or market share. By combining forecast we knowledge of past performance under similar circumstances with forward-looking promotional pricing plans, we can make better buying, allocation, and replenishment decisions. In turn, we will reduce the cost of over-stocks and minimize the frequency of out-of-stocks. Understanding consumer expectations at given times and under different market conditions delivers tangible benefits to both on the demand side and supply side of business.

REFERENCES


