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An Optimization of Inventory Demand Forecasting in University Healthcare Centre

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Abstract. Healthcare industry becomes an important field for human beings nowadays as it concerns about one's health. With that, forecasting demand for health services is an important step in managerial decision making for all healthcare organizations. Hence, a case study was conducted in University Health Centre to collect historical demand data of Panadol 650mg for 68 months from January 2009 until August 2014. The aim of the research is to optimize the overall inventory demand through forecasting techniques. Quantitative forecasting or time series forecasting model was used in the case study to forecast future data as a function of past data. Furthermore, the data pattern needs to be identified first before applying the forecasting techniques. Trend is the data pattern and then ten forecasting techniques are applied using Risk Simulator Software. Lastly, the best forecasting techniques will be find out with the least forecasting error. Among the ten forecasting techniques include single moving average, single exponential smoothing, double moving average, double exponential smoothing, regression , Holt-Winter's additive, Seasonal additive, Holt-Winter's multiplicative, seasonal multiplicative and Autoregressive Integrated Moving Average (ARIMA). According to the forecasting accuracy measurement, the best forecasting technique is regression analysis.

1. Introduction

Many companies do not know their demands and have to rely on demand forecasts to make decisions in production planning, sourcing and inventory management both in long and short term (Kerkkanen, 2010). According to Bon and Chong (2009), there are many factors affecting the frequent change of inventory's demand and those factors are trend, seasonality, and economic factors.Many organizations that utilized inventory optimization reduced inventory levels by up to 25 per cent in one year and enjoyed a discounted cash flow above 50 per cent in less than two years(Study of IDC Manufacturing Insight,2010). In fact, inventory optimization can better address demand volatility and supply variability and thus reducing the risk of both under stocks and overstocks for the organizations to optimize their inventory through demand forecasting.

Healthcare in Malaysia is mainly under the jurisdiction of the Ministry of Health Malaysia. Currently, the nation practices a dual healthcare system and has good access to a blend of government and private healthcare services through a network of hospitals and clinics.In this research, a case study of University Health Centre in University Tun Hussein Onn Malaysia (UTHM) will be conducted. Health services UTHM started back in May 2002, when the Student Health Centre was a part of The Students Affair Office. The University Health Centre provides outpatient services as well as services to emergency cases during office hours.

Under the 10th Malaysia Plan (2011–2015), the government has identified healthcare services as one of the 12 National Key Economic Areas (NKEA) to generate revenue for the country. Healthcare is getting important and important even has becomes necessity for publics in the world.Demand forecasting is one of the most crucial issues of inventory management as forecasts form the basis for the planning of production, transportation and inventory levels (Korpela and Tuominen, 1996). Due to large forecast errors usually negatively affect companies' operational performance, forecast accuracy is often considered as a necessity (Danese and Kalchschmidt, 2011).

Most of the time the healthcare provider will use their own judgement and experience to develop the decision on inventory demand. It means that there is yet have a proper and systematic way to forecast on the inventory demand. It is essential to apply forecasting methods in the aspect of inventory demand to avoid any wastage and lack of inventory situation happen. Besides that, since the actual demand is uncertainty the forecast also difficult to predict. Therefore, ongoing work should be carried out to improve the demand forecasting.

2. Literature Review

2.1 Forecasting

Forecasting means estimating a future event or condition which is outside an organization's control and provides a basis for managerial planning (Kerkkanen,2010). Everyone requires forecasts; the need for forecasts cuts across all functional lines as well as all types of organizations (Hanke and Wichern, 2009) because it is useful in making management decision. According to Panneerselvam (2005), in any organizations, all the functional managers will base their decision on the forecast value. Many companies rely forecasting heavily in decision making for production planning, sourcing and inventory management. Hence, forecasting is used by companies to determine how to allocate their budgets for an upcoming period of time. This is typically based on demand for the goods and services it offers, compared to the cost of producing them.

2.2 Healthcare Forecasting

Forecasting demand for health services is an important step in managerial decision making for all healthcare organizations. This task, which often is assumed by financial managers, first requires the compilation and examination of historical information. Although many quantitative forecasting methods exist, four common methods of forecasting are percent adjustment, 12-month moving average, trend line, and seasonalized forecast.Healthcare financial managers who want to project demand for healthcare services in their facility should understand the advantages and disadvantages of each method and then select the method that will best meet the organization's needs.

2.3 Demand Forecasting

Demand is the need for a particular product or component and it can come from a number of sources (e.g., customer order or producer's good) (Armstrong, 2000).Demand forecasting means estimate of most likely future demand for product under given conditions. Based on the study by Kerkkanen (2010), one of the fundamental managerial tasks is demand forecasting.Demand forecasting is the area of predictive analytics dedicated to understanding consumer demand for goods or services. That understanding is harnessed and used to forecast consumer demand. Knowledge of how demand will fluctuate enables the supplier to keep the right amount of stock on hand.

2.4 Forecasting Techniques

A forecasting technique is a procedure for computing forecasts from present and past values (Chatfield, 2000). According to Lawrence, Klimberg, and Lawrence (2009), forecasting techniques can be divided into two broad categories that are both qualitative and quantitative. Qualitativetechniquesareprojectionsbasedonjudgment,intuition,andinformed opinions,andtheyaresubjectivebynature(Kerkkanen ,2010). Examples of qualitative forecasting techniques include jury of executive opinion, Delphi method, sales force composite and consumer market survey.Quantitative forecasting techniques are used to forecast future data as a function of past

data; they are appropriate when past data are available. Examples of quantitative forecasting techniques such as single moving average, single exponential smoothing, double moving average, double exponential smoothing, regression , Holt-Winter's additive, Seasonal additive, Holt-Winter's multiplicative, seasonal multiplicative and Autoregressive Integrated Moving Average (ARIMA).

3.   Methodology

3.1   Research Design
According to Marican (2006), research design is like a map that clearly presents how a research will be carried out. Research design is the logic that links the data to be collected and the conclusions to be drawn to the initial question of study (Yin ,2009).The research design may be classified in three broad categories depending on objectives and types of research which are exploratory, descriptive and causal (Hair *et. al*., 2003). This study was designed as a descriptive research. A descriptive research may be classified as both qualitative and quantitative.

3.2   Data Collection
This research will involve both qualitative and quantitative method for data collection. For qualitative process, the researcher will ask the problems existed in managing inventory demand in pharmacy, University Health Centre UTHM. For quantitative, the secondary data regarding inventory demand will be collected for data analysis.The most recent 5 years of high demand medicine like Panadol 650mg will be collected so that the forecasting techniques can be applied to analyze the data using risk simulator software and hence the best techniques can be selected to optimize the inventory demand.

4.   Data Analysis

4.1   Data Analysis Background
Data analysis is one of the important elements of the research. After the data being collected, analysis data process will be started in order to determine and find out the result. The research data will be analyzed using Risk Simulator Software. Quantitative analysis was used for this study. Data analysis was committed once the historical data collected from University Health Centre.Before analyzing the data, the historical data were collected from University Health Centre, UTHM. The collected data was inventory demand regarding Panadol 650mg beginning from January 2009 until August 2014.Analyzing started by, firstly, forecast time horizon of collected data will be determined. It is an important preliminary step to selection of the forecasting methods to be used. The determined forecast time horizon was 1 month, a short range forecast. Then, time series plots of the data were constructed and visually inspected the data patterns. After the identification of the data pattern, the study proceeds to select and implement the appropriate forecasting methods based on the data pattern. Finally, the forecast accuracy measurements with the lowest values were selected as the best forecasting method.

4.2   Identification of Data Pattern
A time series are likely to consist one or more of the data patterns such as trend, cyclical, seasonal and horizontal component.
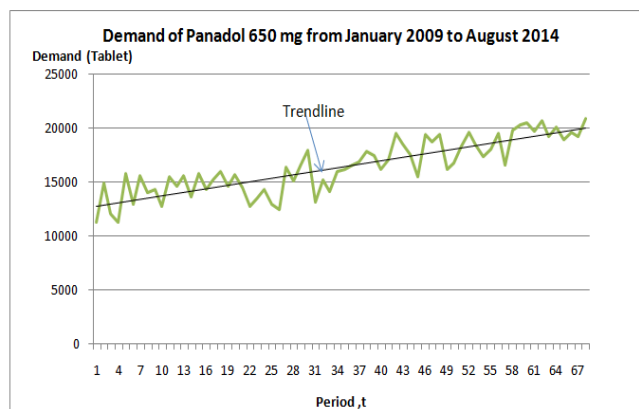
Figure 4.1: Time Series Plot for Panadol 650 mg from January 2009 to August 2014.

As from figure 4.1, it illustrates that there was a significant growth in the time series over an extended period of time. This means that there was a trend component in the time series plot.

4.3   Time-Series Forecasting Techniques
1. Single Moving Average
2. Single Exponential Smoothing
3. Double Moving Average
4. Double Exponential Smoothing
5. Regression Analysis
6. Holt-Winter's Additive
7. Seasonal Additive
8. Holt-Winter's Multiplicative
9. Seasonal Multiplicative
10.ARIMA(Autoregressive Integrated Moving Average)

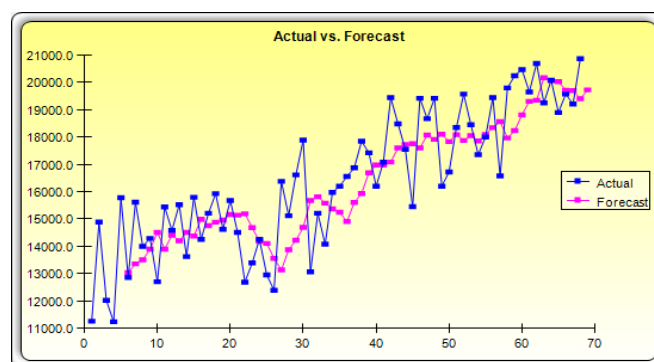*4.3.1   Single Moving Average*

Figure 4.2: Forecasted Result Using Single Moving Average Forecasting Technique

For single moving average, the demand forecast for Panadol 650mg was 19729 tablets in September 2014 (t=69). The RMSE error measurement was 1406.8824.

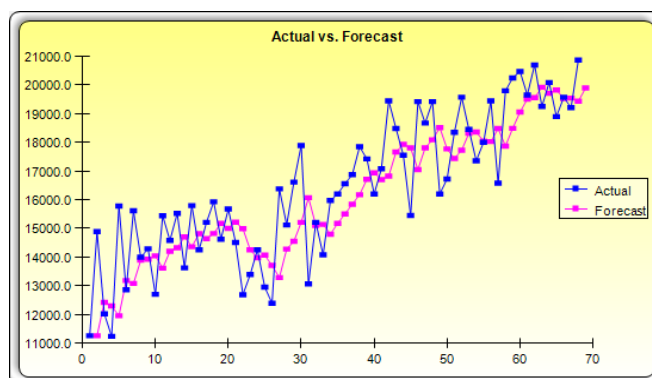*4.3.2   Single Exponential Smoothing*

Figure 4.3: Forecasted Result Using Single Exponential Smoothing Forecasting Technique

For single exponential smoothing, the demand forecast for Panadol 650 mg during September 2014 (t= 69) with the value of 19898 tablets. The error measurement for RMSE was 1501.6296.
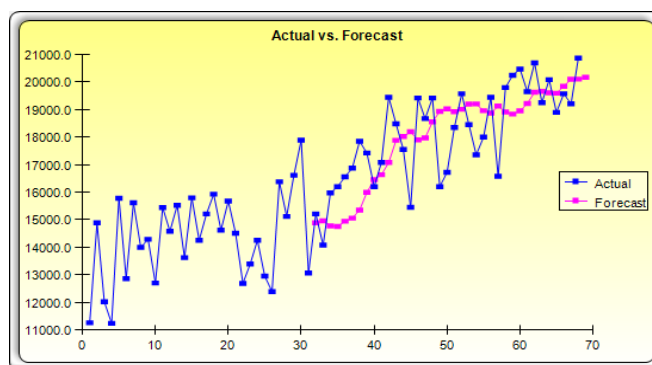
4.3.3   *Double Moving Average*

Figure 4.4: Forecasted Result Using Double Moving Average Forecasting Technique

For double moving average, the demand forecast for Panadol 650 mg in September 2014 (t=69) with the value of 20175 tablets. The RMSE error measurement was 1376.7254.
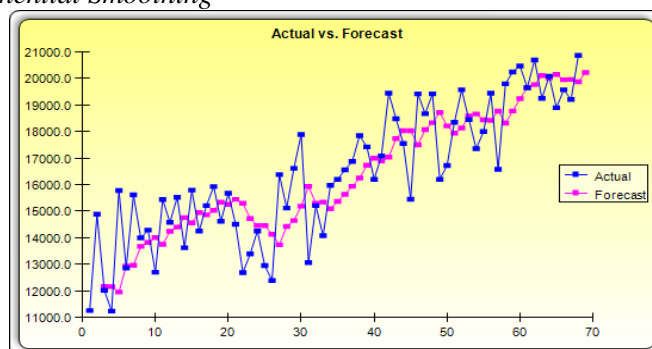
4.3.4   *Double Exponential Smoothing*

Figure4.5:Forecasted Result Using Double Exponential Smoothing Forecasting Technique

For double exponential smoothing, the demand forecast for Panadol 650 mg in September 2014 (t=69) was 20226 tablets. The error measurement for RMSE was 1413.5199.

4.3.5   *Regression Analysis*
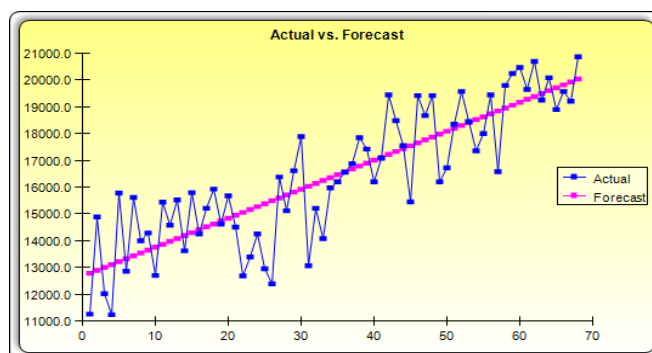
Figure4.6:Forecasted Result Using Regression Analysis

For regression analysis, the error measurement for RMSE was 1334.7793. The forecast using this technique will indicate continuous incremental pattern.
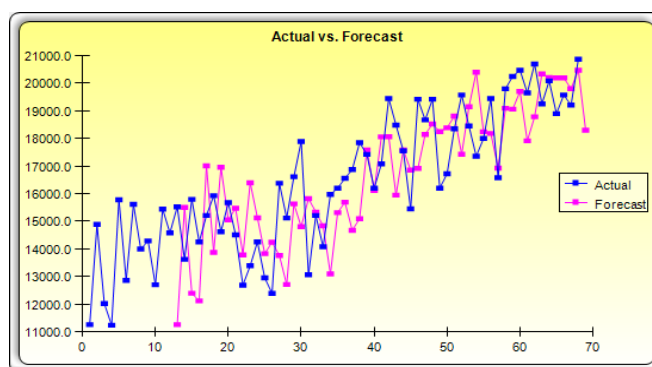
4.3.6   *Holt-Winter's Additive*

Figure 4.7: Forecasted Result Using Holt-Winter's Additive Forecasting Technique

For Holt-Winter's additive, the demand forecast for Panadol 650 mg in September 2014 (t=69) was 18301 tablets. The error measurement for RMSE was 1771.9117.
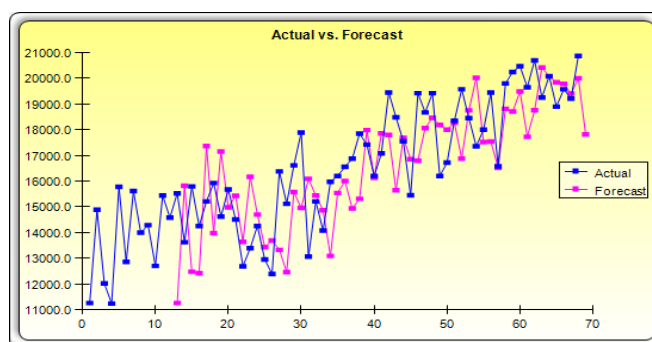
4.3.7   *Seasonal Additive*

Figure 4.8: Forecasted Result Using Seasonal Additive Forecasting Technique

For seasonal additive, the demand forecast for Panadol 650 mg in September 2014 (t=69) was 17817 tablets. The error measurement for RMSE was 1793.8089.

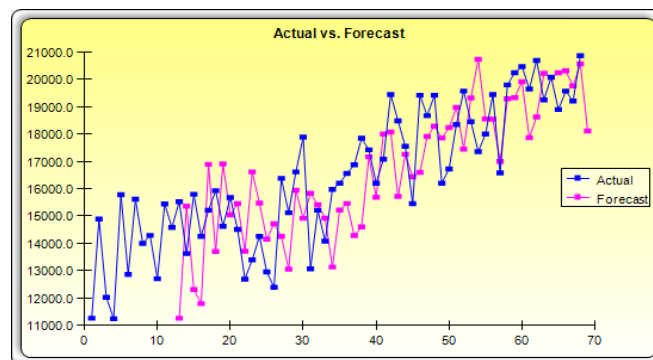### 4.3.8   *Holt-Winter's Multiplicative*

Figure 4.9: Forecasted Result Using Holt-Winter's Multiplicative Forecasting Technique

For Holt-Winter's multiplicative, the demand forecast for Panadol 650 mg in September 2014 (t=69) was 18114 tablets. The error measurement for RMSE was 1818.6557.

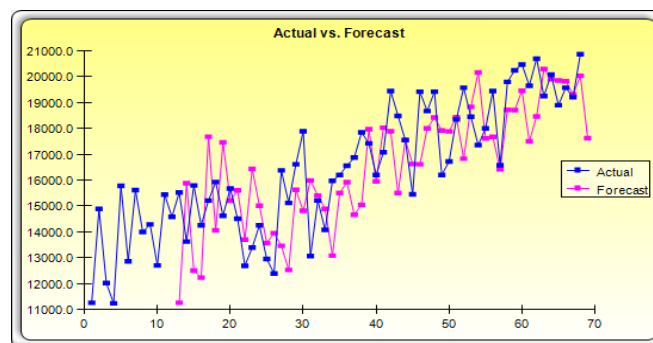*4.3.9   Seasonal Multiplicative*

Figure 4.10: Forecasted Result Using Seasonal Multiplicative Forecasting Technique

For seasonal multiplicative, the demand forecast for Panadol 650 mg in September 2014 (t=69) was 17627 tablets. The error measurement for RMSE was 1849.2047.

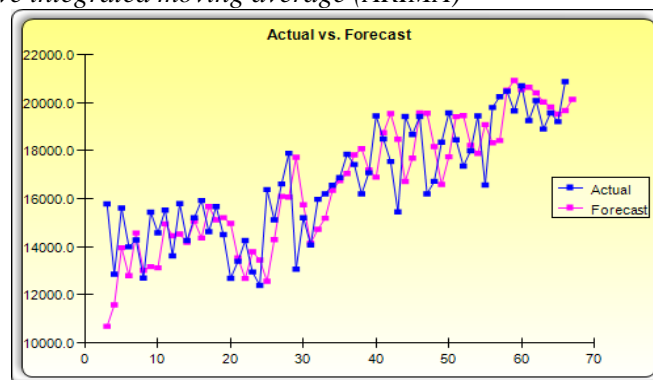*4.3.10   Autoregressive integrated moving average (ARIMA)*

Figure 4.11: Forecasted Result Using ARIMA Forecasting Technique

For ARIMA, it showed that the actual value and the forecast value using ARIMA forecasting technique with parameters p = 2, d = 0, and q = 1 for Panadol 650mg.

4.4   Identification of best forecasting technique

The four forecast accuracy measurements used were RMSE, MSE, MAD, and MAPE. The smaller the forecast error is, the more accurate the forecasting methods.

Table 4.1: Forecasting Accuracy Measurement for 10 Forecasting Techniques

Forecasting Techniques	Ranking
Single Moving Average	3
Single Exponential Smoothing	5
Double Moving Average	2
Double Exponential Smoothing	4
Regression Analysis	1
Holt-Winter's Additive	7
Seasonal Additive	8
Holt-Winter's Multiplicative	9
Seasonal Multiplicative	10
ARIMA	6

Regression analysis technique with RMSE= 1334.7793 was in first ranking as it showed the lowest RMSE value. Next was double moving average technique with RMSE=1376.7254 in second ranking. The single moving average technique in third ranking with RMSE=1406.8824 followed by double exponential smoothing technique with RMSE=1413.5199 the forth ranking. The fifth rank was single exponential smoothing technique with RMSE=1501.6296. The sixth ranking was ARIMA technique with RMSE= 1666.1652. Furthermore, the seventh ranking and eighth ranking were Holt-Winter's additive and seasonal additive with RMSE=1771.9117 and RMSE=1793.8089 respectively. Holt-Winter's multiplicative with RMSE=1818.6557 was in ninth ranking whereas the last ranking was seasonal multiplicative with RMSE=1849.2047.It can be concluded that the best forecasting techniques to optimize the inventory demand is regression analysis.

5. Discussion and Conclusion

5.1   Discussion of Findings
The first research objective is to identify the possible forecasting methods to be applied for inventory demand. In order to achieve the objective, the data pattern needs to be identified first. There were 10 forecasting techniques have been selected for the Panadol 650mg as required for demand forecasting analysis.The second objective is to optimize the inventory demand using the best forecasting method. Once the forecasting techniques are completed to be used for demand forecast process, the forecasting accuracy measurements will be compared among the ten forecasting techniques. The best forecasting methods for the Panadol 650mg is regression analysis.

5.2   Contribution For University Health Centre
With the recommended forecasting method, the University Health Centre is able to produce more accurate forecast which can aid in making precise or reliable decision for the Panadol 650 mg inventory planning.The research can contribute to University Health Centre by assist the pharmacy using statistical forecasting techniques in a better inventory planning and avoid any overstocks or under stocks problems.

5.3   Recommendation For Future Research

The researcher recommends that more inventories should involve in demand forecasting process. This is a way to ensure that more accurate data of inventory demand quantities can be obtained to optimize the overall supply chain for the medicine.Further study should be carried out as well for other field like manufacturing industry. Manufacturing industry really need more accurate forecasting for their production to maximize the profit and ensure safety inventory always existed.

5.4   Conclusion

In a nutshell, the research objectives were achieved. The data pattern was trend and ten forecasting techniques were used. Among the ten forecasting techniques, the best technique which was regression analysis with least forecasting error provided. A better inventory management through forecasting techniques can be implemented and hence improve the quality and performance in a long term period for University Health Centre.

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