A Conceptual Model of Inventory Management System using an EOQ Technique – A Case Study in Automotive Service Industry

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***Abstract*— The successful implementation of inventory management system (IMS) in an organization will give the high impact to their business growth and sustainability. Due to the rapid growth in the automotive industry, the need of having this system in this industry is increase especially in the automotive maintenance business. Although there are varieties of choices of the IMS software available in the market, however, financial constraints become the most important barriers to an organization to implement the system. In this paper, the level of implementation of the IMS in Malaysian automotive service industry is identified. A model of IMS by using the Economic Order Quantity is proposed to be implemented in the independence automotive services workshop as an alternative to the high cost investment of the system in the selected industry. Four products that have the highest usage in the workshop are selected. Three different techniques of forecasting are compared in order to predict the demand of the selected products and to develop the economic order quantity. Based on the results, the data that forecasted by Simple Moving Average technique gives the most accurate data and this technique is selected in the development of IMS model.**

Keywords*— Inventory Management System, Forecasting, Economic Order Quantity, Automotive Service Industry

I. INTRODUCTION

The rapid growth in automotive industry particularly in Malaysia has embarked the industry to transform their operation to the highest level. This including the aftersales market, i.e. automotive maintenance and services industry. Shortage of materials is one of the barriers to this industry in delivering not only the high quality of the maintenance works but also within the short of time. The main reason for this problem is due to the poor in inventory management system. It is important to have a systematic inventory system with low of investment as well provide minimum space for storage purposes.

Although there are varieties of choices of the IMS software available in the market, however, financial constraints become the most important barriers to an organization to implement the system. One of the ways to solve this problem is by doing a forecast and Economic Order Quantity [1-3]. Forecast techniques is use to determine if there is a profit potential for a new service or a product. Somehow, forecasting is not an exact science, yet, successful forecasting often requires a skillful blending of art and science [4]. Experience, judgement and technical expertise all play a role in developing useful forecasting. Generally speaking, the responsibility for preparing a forecasting in business organization lies with marketing or sales rather than operation. But operation-generated forecasting often has to do with inventory requirement, resource needs and time requirement and etc. [5].

On the other hand, Economic Order Quantity identifies the optimal order quantity by minimizing the sum of certain annual cost that varies with order size [6]. There are three type order size models which is the basic economic order quantity model, the economic production quantity model and lastly the quantity discount model [1].

In this paper, the level of implementation of the IMS in Malaysian automotive service industry is identified. A conceptual model of IMS by using the Economic Order Quantity is proposed to be implemented in the independence automotive services workshop as an alternative to the high cost investment of the system in the selected industry.

II. METHODOLOGY

In order to gain the data for this research, qualitative and quantitative methods were chosen. The survey was conducted in order to assess the level of implementation of IMS in automotive service industry. An organization without the system was chosen for the case study purposes.

A. Survey

The survey was done to determine the relationship between forecasting technique, EOQ and inventory management and how far the entrepreneur in Klang Valley region realizes the important of inventory management. Basically the survey aim to discover the level of implementation of inventory management in the automotive service centre. The respondents of this study are from after sales service centre and independence automotive service centre.

B. Case Study

An organization has been chosen based on the voluntarily participation for the implementation of the inventory management system. The data will be collected and analyze using the forecasting technique and economic order quantity. The demand data were gathered from 4 different spare parts that have been identified as having the highest usage in the organization - engine oil, oil filter, air filter and spark plug. Basically, in this study, the following data were collected and analyze:

1. Background of workshop
2. The demand data from three previous months (November 2014 till January 2015)
3. The inventory cost
4. Comparison between three different forecast techniques using Mean Absolute Deviation (MAD), Mean Absolute Percent Error (MAPE) and Mean Squared Error (MSE) [7]

C. Forecasting Technique and Economic Order Quantity

Few equations have been used in this study such as:

1. Forecasting Technique

There are three common measures to summarize the historical error used in this study, MSE, MAD and MAPE.

$$\text{MSE} = \frac{\sum(Actual_t - Forecast_f)^2}{n-1} \quad (1)$$

$$\text{MAD} = \frac{\sum|\ Actual - Forecast\ |}{n} \quad (2)$$

$$\text{MAPE} = \frac{\sum \frac{|\ Actual_t - Forecast_f\ |}{Actual_t} * 100}{n} \quad (3)$$

2. Economic Order Quantity

Economic order quantity is an inventory-related equation that determines the optimum order quantity that a company should hold in its inventory given a set cost of production, demand rate and other variables. This is done to minimize variable inventory costs. The full equation is as follows:

$$Q_0 = \sqrt{\frac{2DS}{H}} \quad (4)$$

Where,

Q_0 = Economic Order Quantity

D = Demand, usually in units per year

S = Ordering cost

H = Holding (carrying) cost per unit

III. Results and Discussion

A. Survey – Awareness of the IMS in Automotive Services

Survey was conducted at 30 organization/automotive services industry at Lembah Klang area. The rate of respondents was 100%. The survey was conducted in order to gain the perception towards the understanding on IMS implementation in the selected industry. The following results were achieved based on this activity:

- Awareness in IMS Implementation

  Based on the survey, 73% of the respondents are aware on the existing of IMS in the industry. Most of the respondents agreed that the implementation of IMS will benefit their organization. Figure 1 shows the percentage of responds received pertaining to the awareness level.

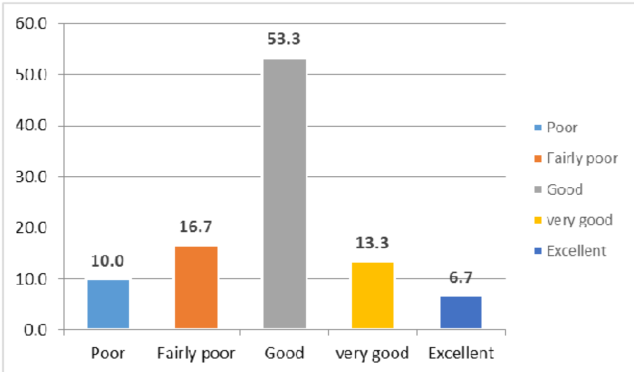

Fig 1: Responds for "Awareness in IMS Implementation"

- Understanding Forecasting Technique and Economic Order Quantity Technique

  Although the highest percentage was gained in the awareness of IMS implementation, the understanding of the techniques and methods used in developing the system amongst the respondents were low. Only 16.7% of respondents have good understanding of Forecasting Technique and Economic Order Quantity Technique. Overall result is shown in Figure 2.

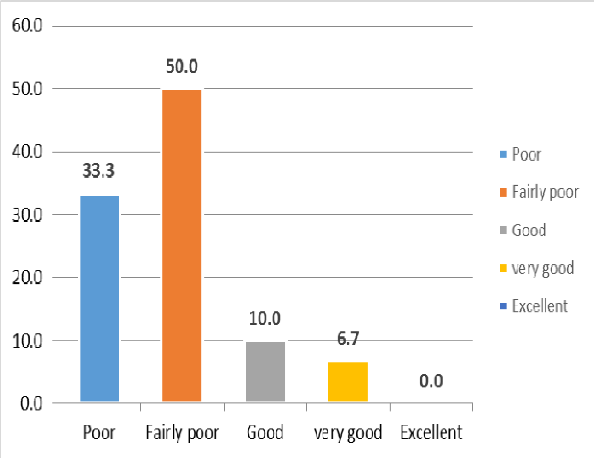

Fig 2: Responds for "Understanding Forecasting Technique and Economic Order Quantity Technique"

- Implementation of IMS in the Organization

The implementation level of IMS in the organization was very low. Amongst the respondents, only 20% of the organization has implemented the system. Based on the results, it shows that majority of the independent automotive services (independent workshop) didn't implement the system due to the high cost of investment. Thus, this study is relevant towards developing the model of IMS that can be used by the industry in elevating their organizational performances. An overall result is shown in Figure 3.

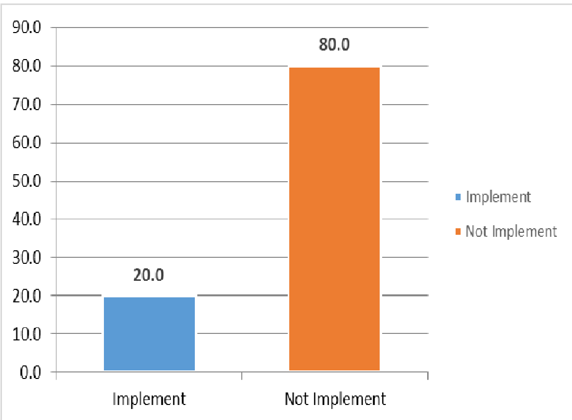

Fig 3: Responds for "Implementation of IMS in the Organization"

B. Case Study at ABC Organization.

ABC Organization is one of the 3S Centre (Sales, Service and Spare parts) for a national car manufacturer located in Kajang area. The company is equipped with 6 service bays, with 25 technical workers. The demand for the maintenance services is increased every month. An inventory management system is needed in order to overcome the spare parts shortage problems during the services works. Based on the data given, 4 types of spare parts (engine oil, oil filter, air filter and spark plug) have been identified in having shortage of supplies during the work done in the organization. Due to overcome the problem, the inventory management system based on the forecasting and economic order quantity are implemented in the organization.

C. Forecasting and Economic Order Quantity

The data on the usage of engine oil, oil filter, air filter and spark plug were collected from Nov 2014 to Jan 2015 based on the daily sale. Three techniques of forecasting were selected i. exponential smoothing, ii. weighted moving average and iii. simple moving average. The forecasting data were gained by using Mean absolute deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE).

- *Exponential Smoothing*

The usage data for 4 parts were calculated and the results shown as in figure 4, figure 5 and figure 6. The usage data were collected for 89 days (working days). For engine oil and oil filter total up to 2602 unit used within the timeframe and total forecast is 2562.402 which made up to 39.5983 ≈ 40 error. While total actual demand for air filter between those three months is 241 of air filter and the amount of this paper forecasted is 232.6359, which only 8 errors. On the other hand, for spark plug the actual demands is 161 and the forecast demand is 159.4759 bringing the total error is only 1.5 ≈ 2. From the results, it is clearly shows that there is the shortage of parts due to high demands of usage.

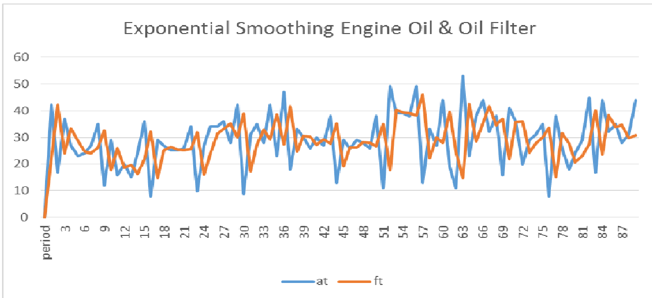

Fig 4: Result for "Exponential Smoothing for Engine Oil & Oil Filter"

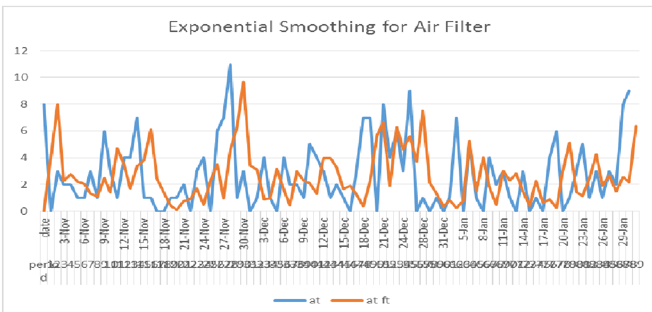

Fig 5: Result for "Exponential Smoothing for Air Filter"

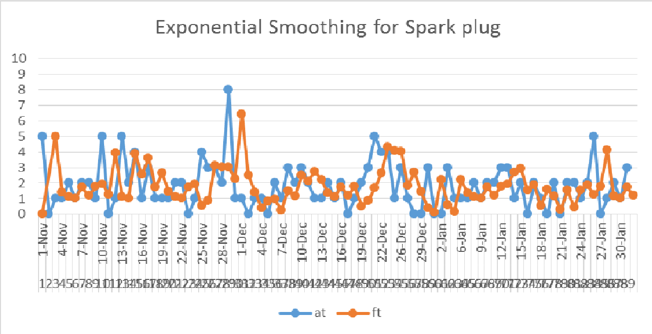

Fig 6: Result for "Exponential Smoothing for Spark Plug"

- *Weighted Moving Average*

Based on the graph in figure 7, figure 8 and figure 9, by using weighted moving average, the variation of forecasting values and absolute errors are larger compared to exponential smoothing technique. This technique is not suitable to be used to forecast the usage quantities for daily basis. Larger data is needed and the technique is more appropriate to be used in forecasting the values for monthly or yearly basis usage.

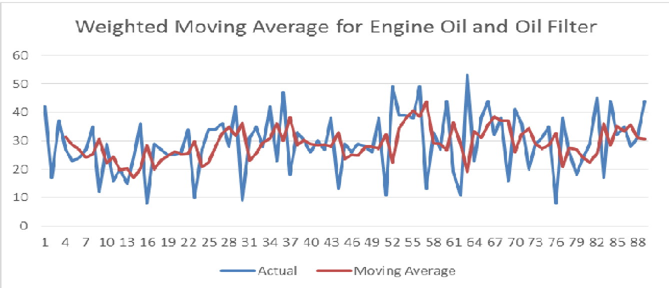

Fig 7: Result for "Weighted Moving Average for Engine Oil and Oil Filter"

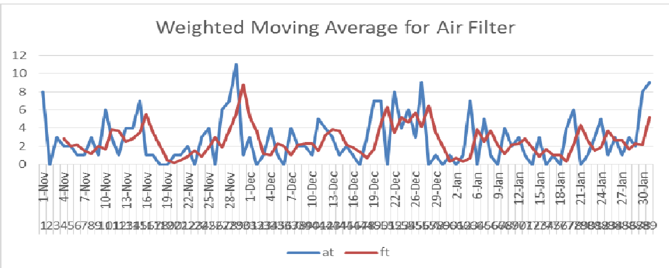

Fig 8: Result for "Weighted Moving Average for Air Filter"

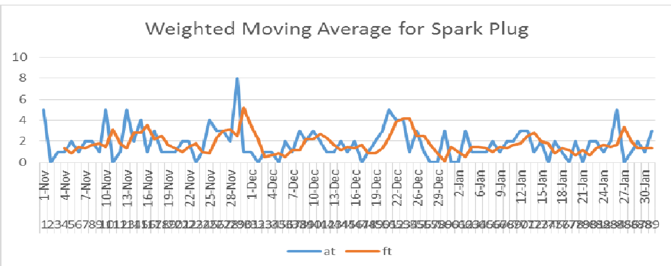

Fig 9: Result for "Weighted Moving Average for Spark Plug"

- *Simple Moving Average*

Basically, the data generated using this technique shows high variation of error ≈ 85%. Compared to three techniques in forecasting, only Exponential Smoothing Technique is suitable to be use in forecasting short timeline usage data (≈90 days). Both other techniques are most appropriate to be used in forecasting larger data with longer timeline (monthly and yearly basis usages). The complete results for Simple Moving Average are shown in figure 10, figure 11 and figure 12.

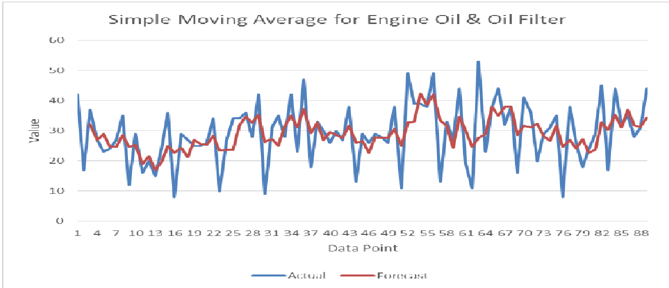

Fig 10: Result for "Simple Moving Average for Engine Oil and Oil Filter"

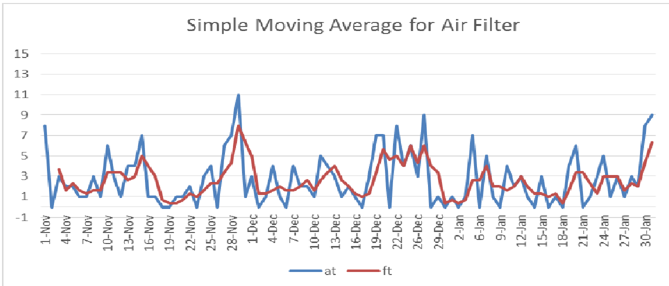

Fig 11: Result for "Simple Moving Average for Air Filter"

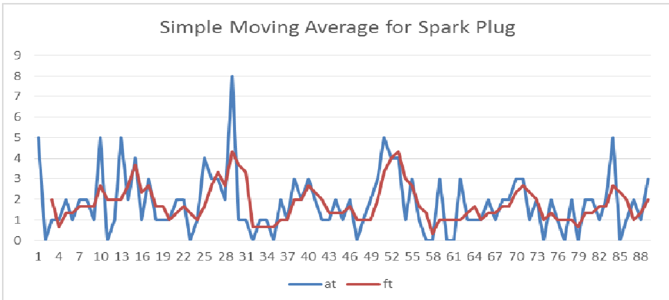

Fig 12: Result for "Simple Moving Average for Spark Plug"

D. *Economic Order Quantity*

Economic order quantity is an inventory-related equation that determines the optimum order quantity that a company should hold in its inventory given a set cost of production, demand rate and other variables. This is done to minimize variable inventory costs [8-10]. Table 1 show the result of EOQ for the data gained (Engine Oil and Oil Filter) from case study in ABC Organization.

Table 1: Result of EOQ for Engine Oil and Oil Filter

Annual Demand	10000
Ordering Cost per Unit	100
Carrying Cost per Unit	15
Annual Workdays	288
EOQ	365.15
Length of Ordering Cycle	10.52
Ordering Cost	2738.61
Carrying Cost	2738.61
Total Cost	5477.23

Table 1 show the EOQ calculation for Engine oil and Oil Filter yearly. Based on the calculation, ABC Organization need to order or restock the parts for 365 in every 10th to 11th days of operation days per month. The cost occurred for restock the parts is RM 2738.61. This method will help the company for allocating the accurate amount for their yearly expenses budget based on the number of services (sales).

Table 2 summarized the forecasting techniques using MAD, MSE and MAPE methods. Comparison of the data generated by all of these methods and the results clearly shows that in applying the forecasting techniques, large amount of historical data are needed in order to achieve high accuracy of forecasting value in daily usage numbers of spare parts selected in this study. Although all the techniques used give different values of errors, the usage of these methods in tracking the error is irrefutable.

Table 2: Result of MAD, MSE and MAPE Techniques for 4 types of spare parts selected in this study

Technique	Product	MAD	MSE	MAPE
Exponential Smoothing	Engine Oil & Oil Filter	10.58	192.13	52.02
	Air Filter	2.35	9.37	74.10
	Spark Plug	1.34	3.32	36.54
Weighted Moving Average	Engine Oil & Oil Filter	8.92	144.32	40.94
	Air Filter	2.21	144.32	71.19
	Spark Plug	1.21	144.32	50.76
Simple Moving Average	Engine Oil & Oil Filter	7.06	65.50	30.40
	Air Filter	1.61	65.50	58.68
	Spark Plug	0.94	1.23	47.71

E. Conceptual Model of IMS in Automotive Service Industry

The conceptual model of IMS in Automotive Service Industry is developed based on the forecasting techniques applied in this study. Although few methods have been used in order to gain the accurate numbers of forecasting data for the particular parts selected, only few method can be considered in developing this model based the available data provided. However, the other techniques can be used in implementing the IMS in an organization if the larger historical data are available. This conceptual model is recommended as a guideline to the organization in this industry to implement the system. Further study are recommended in order to increase the accuracy of data generated to be used as the expenses planning or budgeting purposes. Figure 13 show the proposed conceptual model of IMS in Automotive Service Industry.

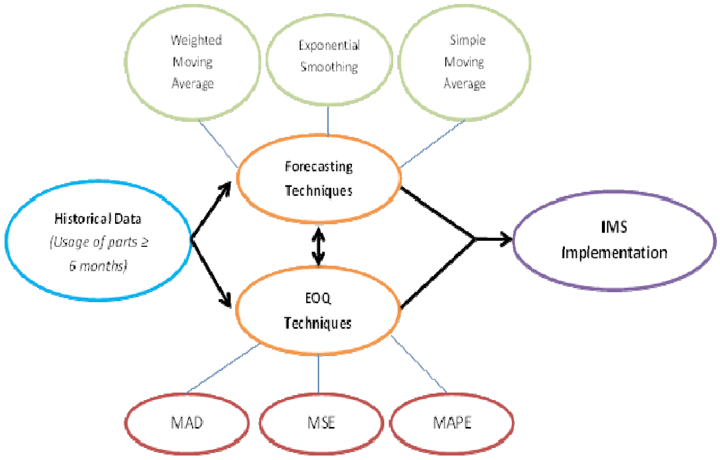

Fig 13: Conceptual Model of IMS Implementation in Automotive Service Industry

IV. CONCLUSION

The implementation of IMS in Automotive Service Industry is important in order to gear up their organizational performances. Three methods of forecasting were selected in this study (exponential smoothing, weighted moving average and simple moving average) and based on the results generated, the technique of exponential smoothing show an accuracy of data gained and can be used in forecasting the value of parts usage based on the historical data provided (daily usage for only 3 months). The other two techniques show inconsistent computational data due to high percentage in errors. However, these techniques are more suitable to be used if the larger historical data can be provided (i.e. 6 months of parts usage). EOQ techniques give higher accuracy of data and it is recommended to be used for implementation of IMS in selected industry. The proposed conceptual model was generated based on the data provided in the study. The model is expected to be the guideline to the automotive services industry in implementing the IMS in their organization.

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