The Study of Demand Forecasting by Using Simple Exponential Smoothing and Simple Moving Average Methodologies with ABC Classification for Aircraft Spare Part; Case Study ABC Airline

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Abstract

This research examined the methodologies of demand forecasting for aircraft spare parts. ABC Classification technique was selected to segment aircraft parts. The criteria for segmentation were 343 items, in group A 74 items, in group B 96 items and group C in 173 items. Groups of 44 products were used to forecast the demand. It was found that 69% accuracy was achieved using Simple Exponential Smoothing and 31% using the Simple Moving Average. Then we compared the exponential trend α = 0.1-0.8. The product had the most accurate prediction using the Simple Exponential Smoothing model α = 0.1. This result shows that companies can improve their efficiency in inventory management and procurement management.

Keywords**:** *Demand forecasting, Exponential smoothing, Sample moving average, ABC classification, Aircraft spare part, Procurement*

1. Introduction

Procurement and Inventory management are the activities that the management team in the organization pay high attention due to the direct effect on the cost, the requirement of customers, and involved with the impact of other operating activities such as manufacturing, distribution, and transportation (Kewtueng, 2008). Therefore, if the organization is able to increase the efficiency on the procurement and inventory management, the other activities will have a positive effect too.

To have a capability in procurement and inventory management there needs to be good planning and precise forecasting of the cargo which will let employees make an appropriate decision. Besides, the operation of inventory will be more efficient, reduce duplicate work, and minimize errors from shortened or excessive products. Nowadays, the airline business has high competition; therefore, the quick response to the needs of passengers, punctual operation management, and cost management is necessary for effective competition. Nevertheless, security, repair, and maintenance at the airport are essential. The demand planning of spare parts and maintenance parts are important.

Since the spare parts of an aircraft vary in price and significance, it is almost impossible to pay attention to demand planning of every single spare part. As a result, ABC classification is used to divide the spare parts into 3 parts according to ADU (Annual Dollar Usage). It is based on the Pareto principle. In ABC classification, A class items contribute 70-80% of total inventory value items. B class items contribute 10-15% and C class items consist 5% of the inventory value of the items (Balaji and Kumar, 2014).

ABC airline is a medium size organization with regional, local and international service. It has more than 30 aircrafts. It procures the spare parts and maintenance parts from global suppliers, which affect the different lead-times of the various receiving products. Because of the difficulty in planning and controlling of inventory for spare parts, the negative impact on the timing and cost are the main obstacle. Thus, the researcher was interested to find out the forecasting model to improve and develop the demand planning for the spare parts at the airport for first class airlines.

2. Objectives

1. To study the suitable demand forecasting methodology for the aircraft spare part
2. To study the effect of demand forecasting methodology toward to efficiency of aircraft spare part requirement planning
3. To improve the procurement and inventory management

2.1 Research Questions

1. Are the patterns of demand forecasting of aircraft spare parts suitable to the demand of ABC airlines?
2. How appropriate is the forecasting that effects to the efficiency of demand planning?

3. Material and Method

The materials and research methodology used in this study are the following:

3.1 Theoretical foundation and literature review

The research study of the demand forecasting for the aircraft spare part has a purpose of improving the procurement's capability and inventory management of the repair and maintenance department of ABC Airline Company limited. The related literature review as below:

3.1.1 The literature of procurement and sourcing management

The procurement and sourcing management was involved with the finding, ordering and selecting of products to reach the organization objective. It was the support activity or service activity (Jatarongkakul, 2001). Nevertheless, for some organizations the procurement and sourcing management was the primary strategy for the competitive advantage (Sánchez-Rodríguez, & Hemsworth, 2005). The pattern of operation for procurement and sourcing management was different, but the similarity in the objective was the minimization of cost in the organization.

The procurement and sourcing management not only focused on minimizing cost but also involved collaboration with other organizations to make the excellent flow of products. The idea of procurement and sourcing management had many concepts that depended on a variety of factors such as the concept from Tanner, Wölfle, Schubert and Quade (2008) which described that there were two types of procurement and sourcing management. One was the direct goods, and the second was the maintenance repair and operation goods: MRO). Tanner et al. (2008) indicated that the products used for manufacturing were involved with inventory management and planning to get the products to operate more efficiently.

The concept of inventory management and classifying the product was based on ABC strategy with the idea of inventory segmentation which contained three groups by value and quantity. Group A consisted of a few items or SKU around 5-15% but was precious value over 70-80% of inventory. Group B had less value than group A and contained 15-30% of items and had a value below 30% of inventory. Group C had the lowest value and was less important, which was composed of high volume products approximately 50-60% but had less value at 5-10% of inventory (Ramanathan, 2006).

To manage the inventory effectively, it needed to measure the control each type of product. The record of movement of product group A needed special concern and it should be precise in the record. The order and distribution of the product requested clear transparent records by using the demand evaluation correctly. Product group B did not have many orders like group A, therefore, the record could be checked based on the period of time by the management team such as every 3-4 months. The safety stock and EOQ system will be applied for product group B. Product group C had the lowest value and the record for movement of product would be verified every half year or every year (Hadi-Vencheh, 2010).

3.1.2 The literature of demand forecasting method

The forecasting theory was the prediction of something in the future and used the data to make a better decision. The forecasting had been divided into financial forecasting, marketing forecasting, and production forecasting. The forecasting model had been provided to two patterns namely qualitative methods, which was using emotional feeling and experience for forecasting, and the quantitative methods,

which was using mathematics, and previous data for forecasting such as causal methods, and time series methods.

The causal methods used the data from the past to forecast the future under hypotheses of the previous information could be used to predict the future by using the mathematical process. The data that was collected were the trend data that changed in the same direction, the seasonal data that changed in the same period every year, the cycle data that was the long term data which occurred in the same environment, and the random data which possessed uncertainty and came from unpredictable events and difficult to forecast.

While the time series method had different data and was divided into 4 types.

1. Naive forecast which used the latest information to forecast
2. Moving average, which found the mean of sale volume by using demand of products in three duration. The formulation was:

$$\text{Moving Average} = \frac{\sum \text{demand in period n period}}{n}$$

3. Weight moving average was calculated the average of demanding of products in the duration of time by weighing each duration differently. Normally, it would use the current weigh the most and use the other based on the period. The formulation was:

$$\text{Weight Moving Average} = \sum (\text{demand in each period x weight value})$$

Where the weight value is from 0 to 1

4. Exponential smoothing was used to find the weight moving average by specifying the weighing or smoothing with α. The α value from 0 to 1 used formulation of exponential smoothing

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

where F_t = demand forecasting value in t period
D_{t-1} = actual demand value in 1 time period before forecasting time
F_{t-1} = demand value in 1 time period before forecasting time
α = smoothing weight

To forecast the demand of the products they needed the verification of measuring forecast errors to find out the properly forecasting pattern. Jay Heizer and Bary Render (2006) indicated that to verify the measuring forecast errors had three methods.

1. Mean absolute deviation (MAD) used the total amount of absolute value from the forecasting and divided by the number of data's duration (n).

$$\text{MAD} = \frac{\sum \left| \text{Actual value} - \text{Forecasting value} \right|}{n}$$

2. Mean square error (MSE) used the different value between the actual value and forecast value and squared to delete the plus and minus variables.

$$\text{MSE} = \frac{\sum (\text{Actual value} - \text{Forecasting value})^2}{n}$$

3. Mean Absolute Percent Error (MAPE) was the process of calculation function for the forecast and the eventual outcomes.

$$MAPE = \frac{\sum \left| \left(\frac{\text{Forecasting value} - \text{Actual value}}{\text{Forecasting value}} \right) \text{x } 100 \right|}{n}$$

3.2 Research Methodology

This research was a qualitative experimental study, and the methodology was to:

1. Study the aircraft spare parts with a shortage parts problem in the Maintenance department and to segment the group of products based on the ABC classification
2. Bring the data of aircraft spare part class A items, which are the most valuable items to forecast by using the moving average and exponential smoothing method. Moving average is one of the widely known technical indicators used to predict the future data in time series analysis. Exponential smoothing is a very popular forecasting method; it is easy to understand and use.
3. Find the error value of the two types of forecasting by using mean absolute deviation (MAD).
4. Compare and analyze the MAD value of these two forecasting methodologies.
5. Adapt the suitable forecasting method to improve procurement and inventory management.

4. Results and Discussion

4.1 Results

The researchers collect 343 items of aircraft spare parts from the database to analyze and arrange the type of products from the ABC classification by focusing on the value per year in US dollars for segmentation. The arrangement of the highest value to the lowest value is presented in Table 1.

Table 1 The product segmentation from ABC classification

Product Type	No. of Aircraft Spare Parts (Item)	Percentage of Aircraft Spare Parts	Total Value (USD)	Percentage of total value
A	74	21.5	740,730.20	72.20
B	96	28	238,581.6	23.25
C	173	50.5	46,626.89	4.55
Total	343	100	1,025,938.69	100

Product group A has 74 items which was 21.5% of the total products and the value of the products was $740,730.20 which was 72.20 % of the total value of products.

Product group B has 96 items which was 28% of the total products and the value of the products was $238,581.6 which was 23.25 % of the total value of products.

Product group C has 173 items which was 50.5% of the total products and the value of the products was $46,626.89 which was 4.55 % of the total value of products.

The researcher selected product type A for forecasting due to the highest value of the products. The forecasting used the time series methods and the past 24-month's data for forecasting. The results as follows:

1. The result of 3 months moving average forecasting
2. The result of exponential smoothing forecasting

The formulation of 3 the months moving average forecasting was:

$$Ft = (At\text{-}1 + At\text{-}2 + At\text{-}3) / 3$$

The example of demand forecasting of spare part at the airport No.5A1711

F4 = (20+5+0) / 3 = 8.33 or approximately 9 pieces

The forecasting of the aircraft spare parts for the part no. 5A1711 in 10 months as presented in Table 2.

Table 2 The forecasting of aircraft spare part for part no. 5A1711 in 10 months

Month	Actual demand	Forecasting value
1	20	-
2	5	-
3	0	-
4	45	(20+5+0) / 3 = 9
5	80	(5+0+45) / 3 = 17
6	35	(0+45+80) / 3 = 42
7	19	(45+80+35) / 3 = 54
8	66	(80+35+19) / 3 = 45
9	40	(35+19+66) / 3 = 40
10	42	(16+66+40) / 3 = 41

The researcher forecasted the demand of the aircraft spare parts for product type A totaling 74 items, each item for 22-forecast value. The researcher brought that forecast value to calculate the mean absolute deviation to consider the precision of the forecasting.

The formulation of exponential smoothing forecasting:

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

The example of the demand of product No. 5A1711 used exponential smoothing forecasting setting the exponential smoothing from 0.1 to 0.8 by forecasting the 0.1 first.

$$F2 = \alpha D1 + (1-\alpha) F1 *$$
$$F2 = 0.1(20) + (1-0.1)20 *= 20$$

* Setting default forecast is equal to the demand of product in the first period.

The researcher took the second month of forecasting value to predict the third month.

$$F3 = \alpha D2 + (1-\alpha) F2$$
$$F3 = 0.1(5) + (1-0.1)\ 20 = 18.5$$

The researcher took the third month forecasting value to predict the fourth month and so on until getting the present value, which is presented in Table 3

Table 3 The example of exponential smoothing forecasting setting the exponential smoothing equal to 0.1 of aircraft spare part.

Month	Actual Demand	Forecasting Value
1	20	-
2	5	0.1(20) + (1-0.1)20 = 20
3	0	0.1 (5) + (1-0.1)20 = 18.5
4	45	0.1 (0) + (1-0.1) 18.5 = 16.65
5	80	0.1(45) +(1-0.1) 16.65 = 19.49
6	35	0.1(80) +(1-0.1) 19.49 = 25.54
7	19	0.1(35) +(1-0.1) 25.54 = 26.49
8	66	0.1(19) +(1-0.1) 26.49 = 24.89
9	40	0.1(66) +(1-0.1) 24.89 = 29
10	42	0.1(40) +(1-0.1) 29 = 30.1

The researcher forecast the demand of the aircraft spare parts for product type A from the total amount of 74 items, each item for 24-forecast value. The researcher brought the value to find out the mean absolute deviation to compare the precision of forecasting. The comparison of mean absolute deviation for the demand forecasting of aircraft spare part no. 5A1711 is shown in Table 4.

Table 4 Comparison of mean absolute deviation

Month	Actual demand	Moving Average	Error	Exponential (α = 0.1)	Error
1	20	-	-		
2	5	-	-	20	15
3	0	-	-	18.5	18.5
4	45	9	36	16.65	28.35
5	80	17	63	19.49	60.51
6	35	42	7	25.54	9.46
7	19	54	35	26.49	7.49
8	66	40	26	24.89	41.11
9	40	41	1	29	11
10	42	41	1	30.1	11.9
		MAD	**24.17**	**MAD**	**22.59**

The comparison of 3 months moving average forecasting and exponential smoothing forecasting from 0.1 to 0.8 by using mean absolute deviation to verify the precision of forecasting is presented in Table 5.

Table 5 Comparison of forecasting accuracy for 74 items of aircraft spare parts.

Number of item for aircraft spare parts	3 Months moving average	Exponential Smoothing							
		α 0.1	α 0.2	α 0.3	α 0.4	α 0.5	α 0.6	α 0.7	α 0.8
	23	32	2	1	0	4	1	7	4

Table 5 illustrated the precise model of forecasting by using the 3 months moving average forecasting and exponential smoothing forecasting which provided the precision at 23 out of 51. The exponential smoothing forecasting contributed to the proper forecasting of demand of the spare parts for the aircraft in product type A more than 3 months moving average forecasting.

4.2 Discussion

The 343 items of aircraft spare parts were collected and analyzed by using ABC classification. 74 items of aircraft spare parts were in A class items, which was 21.5% of the total products volume and 72.20 % of total products value. Class A items were forecasted by using 3 months moving average and exponential smoothing forecasting method. The forecasting value of 3 months moving average and exponential smoothing were used to find out the mean absolute deviation to compare the precision of forecasting.

The mean absolute deviation comparison of 3 months moving average forecasting and exponential smoothing forecasting from 0.1 to 0.8 found out that the exponential smoothing forecasting method provided more precise than the moving average forecasting. The exponential smoothing forecasting by using exponential smoothing equal to 0.1was most suitable for forecasting class A aircraft spare parts. The accuracy of exponential smoothing forecasting was 51 out of 74 items; and the exponential smoothing forecasting with alpha equal to 0.1 provided the precision at 32 out of 51.

From this research study, it contributes to the suggestion for entrepreneurs to consider the method of forecasting that helps the organization to manage the demand of the products efficiently and minimize the cost of ordering and storing products wisely. Nevertheless, the limitation of the study was the method of

forecasting that was presented in this study used only 2 methods. Other methods should be provided in the next research for more generalizable.

5. Conclusion

The proper forecasting for aircraft spare parts class A was the exponential smoothing with alpha equal to 0.1, which contained of 32 items out of 74. For entrepreneurs would like to adapt the exponential smoothing forecasting method, they should consider external factors that affect the demand of spare parts for the aircraft to manage the demanding efficiently. The suggestions for next research is to compare the other forecasting methodologies such as simple linear regression or multiple regression.

6. References

Balaji, K., & Kumar, V.S., (2014). Multicriteria Inventory ABC Classification in an Automobile Rubber Component Manufacturing Industrial. *Proceedings of the 47th CIRP Conference on Manufacturing Systems.* 463-468.

Jatarongkakul, A. (2001). *Purchasing. Bangkok*. Thammasart University, Thailand

Jay Heizer and Barry Render. (2006). *Principle of operation management.* 6th Edition. New York: Pearson Prentice Hall.

Hadi-Vencheh, A. (2010). An improvement to multiple criteria ABC inventory classification. *European Journal of Operational Research, 201*(3), 962-965.

Kewtueng, J. (2008). *Inventory management for mro products, case study of SG beverage manufacturing*. Thai Chamber University, Thailand

Ramanathan, R. (2006). ABC inventory classification with multiple-criteria using weighted linear optimization. *Computers & Operations Research*, *33*(3), 695-700.

Tanner, C., Wölfle, R., Schubert, P., & Quade, M. (2008). Current trends and challenges in electronic procurement: an empirical study. *Electronic Markets*, *18*(1), 6-18.

Sánchez-Rodríguez, C., & Hemsworth, D. (2005). A structural analysis of the impact of quality management practices in purchasing on purchasing and business performance. *Total Quality Management and Business Excellence*, *16*(2), 215-230.