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A COMPARATIVE STUDY OF DEMAND FORECASTING FOR AFTERMARKET PARTS IN HEAVY EQUIPMENT INDUSTRY (PT XYZ CASE STUDY)

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ABSTRACT

The global economic crisis has reached the world today, forcing many customers to become more cost aware in their search for better quality and service, and forcing corporate organizations to discover more effective and efficient ways to compete among them. The main objective of this research is to choose the best forecasting method to predict the demand for spare parts at PT XYZ highly fluctuating, and to avoid or minimize stockouts. The demand for high-priced spare parts and capital goods is considered discontinuous if it is random and contributes a large part of the inventory value. Fluctuating demand for goods will be difficult to predict, and inaccurate estimates can cause huge losses for the company due to obsolescence of spare parts or unfulfilled demand for spare parts. Running a successful company operation today requires organizational strength to supply the needs of its customers. This study discusses the appropriate demand forecasting method for the fluctuation demand for spare parts products at an Indonesian company named PT XYZ. This study compares four forecasting methods to predict the demand for spare parts at PT XYZ is the ABC Analysis, the Moving Average, the Simple Exponential Smoothing (SES) and Exponential Smoothing (ES) with Trend Adjustment. This study uses demand data for 2017-2020 to forecast demand in 2021 and uses the optimum alpha value of 0.4065 for SES which is obtained by calculating using MS Excel Solver and uses alpha value of 0.5 and beta value 0.3 for ES with Trend Adjustment. The performance of this forecasting method is determined based on the smallest mean absolute percentage errorand the level of forecasting accuracy (tracking signal) which is close to zero, and the results of this study indicate that the use of the Exponential Smoothing with trend adjustment method has the best performance compared to the other three methods.

Keyword: *ABC Analysis, Aftermarket Demand, Exponential Smoothing with Trend Adjustment, Forecasting Method, Moving Average, Simple Exponential Smoothing*

1. Background

At this time the global economic recession has hit the world and makes customers more costconscious while trying to find a better level of quality and service, which requires corporate organizations to find more effective and efficient ways to compete. Running a successful company operation today requires organizational strength to supply the needs of their customers (Killmeyer et al., 2012).

Companies can minimize costs and deliver items to customers faster by effectively managing the supply chain. This is accomplished by maintaining strict control over internal inventories, internal manufacturing, distribution, sales, and company vendor stocks (Hayes, 2020).

In this research, a comparison of models and methods is used to estimate aftermarket needsto improve performance and reduce company operating costs, which is more complete by adding aftermarket spare parts to spare parts products. The development of the heavy equipment market has directly opened spare parts business opportunities.

In February 2019, PT DEF, which owns 100% of PT XYZ,took a corporate action by merging the two firms, PT XYZ and PT HIJ, to increase performance and lower operational expenses. PT XYZ is Indonesia's largest and most well-known agricultural equipment distributor, offering the greatest brands such as Kubota, Komatsu, and Kirloskar, as well as aftermarket and spare parts goods.

PT XYZ also committed to continue to make improvements in order to provide the bestsolutions for customers. In improving the quality of after-sales service, the company aims to ensurethat customers do not have to worry when facing the problems when running their business operations so that they can achieve the targets.

In this research, we will focus on forecasting for aftermarket products at PT XYZ, after merger activity with PT HIJ.

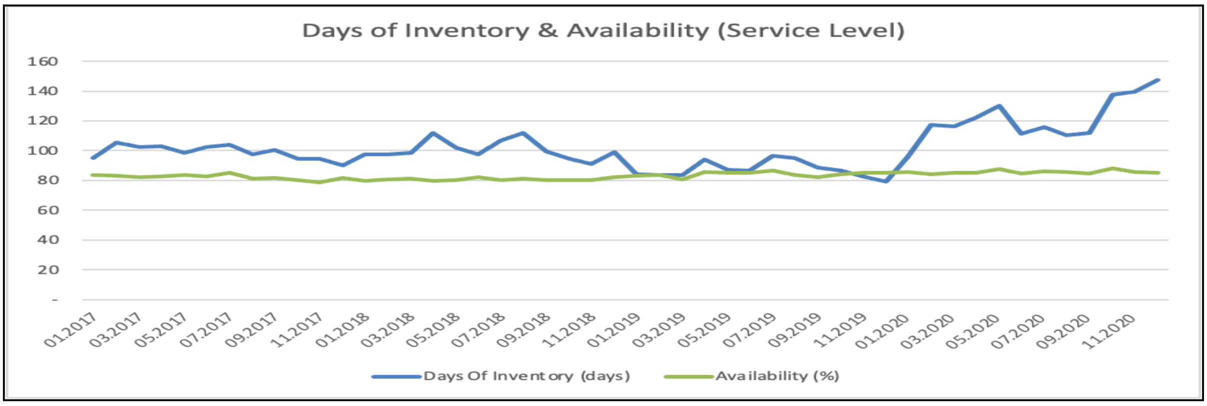

Figure 1. Days of Inventory PT BP, period 2017 – 2020
Source: CPMD Team Analyst PT XYZ

From the data on Figure 1, the researchers took from the company's ERP from Jan 2017 to December 2020, the following facts can be seen: first, Days of Inventory (blue line) from Jan 2017 to December 2020 most of them are always above the 90-day target and even since the COVID-19 pandemic has spread in Indonesia days of inventory tend to rise sharply. This has the effect of increasing and inefficiency of working capital that must be provided by the company. Second, the level of customer satisfaction, which can be seen from the level of availability of spare parts, also cannot be met by the company where the level of availability (green line) has also never reached the target of 90%, this has an impact on not achieving customer satisfaction and it ispossible that sales will not be achieved because unavailability of spare parts.

So, we need the appropriate inventory policy that can quickly capture the fluctuations of customer demand in order to obtain the ideal balance to meet customer demands and optimize working capital. Currently, the company uses the ABC analysis forecasting method without being able to see the accuracy and error of the results.

The accuracy of estimation are a real problem in many companies, including PT XYZ. The company has a problem related to estimate the forecasting of demand after sales. Management realizes that the current method of forecasting can be improved or replaced with something else.

1.1 Problem Identification

Given the foregoing context, the following problems are formulated in this research:

1. How does XYZ estimate the current demand for parts?
2. How to improve Aftermarket spare parts demand forecast, and determine which forecastingmethod can minimize forecast error considering the existing marketing trends?

1.2 Research Objectives

Based on the formulation of the problem that has been explained by previous researchers , the purpose of this study is to analyze the current forecasting model implemented by the company for after-market spare parts and to determine an alternative forecasting model that suits the company by the considering marketing trends.

1.3 Research Scope

According to the findings, based on the research background that has been described previously, the problem boundaries of this study are:

1. This research will be implemented in the company PT XYZ which is engaged in aftermarket products with primary data from January 2017 until June 2021.
2. This research will focus on the demand forecasting of the aftermarket spare parts filter.

1.4 Research Contribution

The results of this study can be used as an additional reference for the aftermarket parts forecasting, and it can also be used by PT XYZ to improve the forecasting models of aftermarket part demand.

2. Literature Review

2.1 Forecasting Methods

Forecasting is a method for planning and controlling production. which is defined as an effective and efficient planning tool. For example, predicting product demand, forecasting prices during the current pandemic, and so on. These results are used as information to determine the company's next activity. Forecasting methods are divided into two, forecasting qualitatively and forecasting quantitatively. Qualitative forecasting is forecasting using opinion and descriptive analysis and quantitative fore-casting is forecasting using a mathematical model calculation (Shashi, et al, 2019).

2.2 Quantitative Forecasting Method

To forecast demand, quantitative forecast-ing models use mathematical methodolo-gies basedon historical data and can include causal variables. Time series forecasting assumes that the future is a continuation of the past, hence previous data can be utilized to estimate future demand. Cause- and-effect forecasting assumes that one or more independent variables (independent variables) are related to demand and may thus be utilized to forecast future demand, as known as Regression Model (Klimsova & Lobban, 2008).

2.3 Exponential Smoothing

Exponential smoothing forecast is a sophisticated weighted moving average forecasting technique in which the forecast for next period's demand is the current period's forecast adjusted by a fraction of the difference between the current period's actual demand and forecast. This approach requires less data than the weighted moving average method because only two data pointsare needed. Exponential smoothing is one of the most extensively used forecasting techniques due to its simplicity and low data requirements. Like the other time series models, this one is best for data with little trend or seasonal trends. With a number closer to 1, the exponential smoothing prediction places a higher focus on recent data, resulting in significant reduction in the error in the forecast. As a result, a high number indicates that the model is more responsive to recent demand changes. When has a low value, the model gives more weight to historical demand (which is contained in the prior forecast) and responds to changes in demand more slowly (Bordoloi et al, 2019).

2.4 Measurement Error / Forecasting Validation

According to Piasecki (2009) those estimation forecast errors have done to get the best forecasting methods. The estimation method of the forecasting accuracy level which is used in this research was Mean Absolute Deviation (MAD) and Mean Absolute Percent Error (MAPE). Any forecasting project's ultimate purpose is to produce an accurate and unbiased forecast. The costs of lost sales, safety stock, dissatisfied customers, and loss of goodwill are all examples of cost.

2.5 Time series forecasting

The time series method is a forecasting method that connects the dependent variable (the variable being sought) with the independent variable that influences it, then the variable is linked tothe time of week, month, or year (Killmeyer et al, 2014).

2.6 Moving Average

Piasecki (2009) stated that the simple moving average forecasting assumption as if the future demand does similiar with previous demand. The greater the number of forecast data periods, the greater the fluctuation in demand.

3. Research Method

The research approach used is descriptive analysis research with the aim of explaining and describing the object of research through qualitative and quantitative data. Qualitative data describes the description of the activities carried out by the company in managing inventory. Quantitative datain the form of transaction data, inventory data, quantity data of the arrival of goods at the company, the activities carried out by the company are recorded and evaluated through the SAP system application. The research conducted at PT XYZ, especially the Storage System section, useddata for 48 months from January 2017 to December 2020. From the ABC analysis data conducted by the company, 5 items were taken in category A (stockkeeping unit), where the product was always included in category A in a row during the period 2017 to 2020. Category A products that were studied with consideration from this category are products that are important, make a big contribution and need the most attention (Muller, 2011). The data are grouped into qualitative and quantitative data categories, which are obtained by observing, recording and documenting. The qualitative data of this research are in the form of notes, minutes of meetings, reports and results of internal meetings between divisions within the company, while quantitative data is obtained from company data in the form of Management Review (MR) data, monthly sales data, quantity data of goods arrivals and relevant collected data from 2017 to 2020.

As previously mentioned, the purpose of this study is to estimate the demand for spare parts at PT XYZ. This study compares four popular forecasting methods for fluctuation demand, namely ABC Analysis, Moving Average, Simple Exponential Smoothing, and Exponential Smoothing with Trend Adjustment. The following is a research scheme carried out by looking at the following Figure 2.

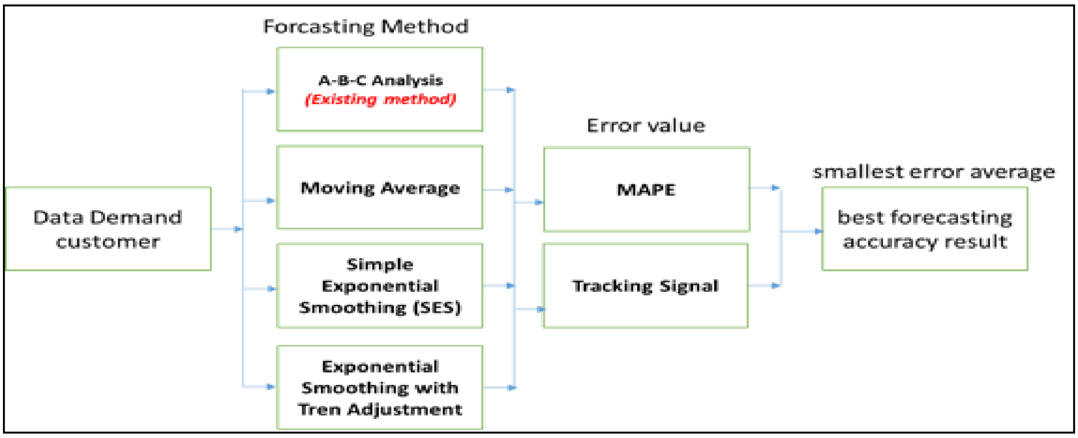

Figure 2. Research Scheme

3.1 ABC Analysis

The ABC analysis method using Mortality and Trend analysis (Up and Down). ABC analysiswork with 1-year historical sales is divided into 3 trimesters (period A, B, & C) where A is the last4 months and trend is observed for the 3 periods: increase, decline, or fluctuated to determine forecast. The forecasting formula for each of these conditions is as follows:

a. Demand Increase (Up Trend)

$$F_{t+1} = \frac{A}{4} \quad \text{.............................} \ (1)$$

b. Demand Decrease (Down Trend)

$$F_{t+1} = \frac{A+B}{8} \quad \text{.............................} \ (2)$$

c. Demand Decrease (Down Trend)

$$F_{t+1} = \frac{A+B+C}{12} \quad \text{.............................} \ (3)$$

where F_{t+1} = value of forecast result

A,B,C=

Bulan ke-											
1	2	3	4	5	6	7	8	9	10	11	12
C				B				A			

3.2 Moving Average

The simple moving average forecast uses historical data to generate a forecast and works well, when the demand is fairly stable over time. The formula for the n-period moving average forecast is shown below:

$$F_{t+1} = \frac{\sum_{i=t-n+1}^{t} A_i}{n} \quad \text{............................} \ (4)$$

where F_{t+1} = forecast for period t+1

n = number of periods used to calculate moving average

A_i = actual demand in period i.

3.3 Simple exponential smoothing (SES)

The method starts with determining the initial level (Lo), which can be the actual demand of the first period or the average demand (Di) in all periods [7], such as in the following formulation:

$$L_0 = \sum_{i=1}^{n} Di \quad \text{.............................} (5)$$

For the subsequent periods, the level is determined using the following formulation, with as the smoothing constant and t is the time period.

$$L_0 = \alpha\ D_{t+1} + (1-\alpha)\ L_t \text{.................} (6)$$

Then, the forecasted demand for the next period is determined using the following formulation. It indicates that forecasting projection for the next period is equal to the level at period t.

$$F_{t+1} = L_t \text{...} (7)$$

3.4 Exponential Smoothing with Trend Adjustment

Exponential Smoothing with Trend Adjusted method of forecasting is a more sophisticated forecasting method. The idea behind Exponential Smoothing with Trend-Adjusted for making forecasts consists of using an exponential smoothing form of forecasting, but with a correction to account for a trend (when it exists). Otherwise, when there is a trend and it is not accounted for with exponential smoothing, its forecasts tend to lag behind. The exponential smoothing with trend adjusted forecast costs of two parts: The exponentially smoothed forecast (S_t) and the exponentially smoothed trend (T_t).

Step 1: $S_t = \alpha\ (A_t) + (1-\alpha)\ (S_{t-1} + T_{t-1})$............................ (8)

Step 2: $T_t = \beta\ (S_t - S_{t-1}) + (1-\beta)\ T_{t-1}$ .... (9)

And then calculate the exponential smoothing with trend adjusted is (F_{t+1}) computed as:

Step 3: $F_{t+1} = S_t + T_t$ .... (10)

Where, F_{t+1} = forecast for period t + 1

S_t = forecast for period t

T_t = trend correction

A_t = actual demand for period t

α, β = smoothing constant ($0 \leq \alpha, \beta \leq 1$

The ultimate goal of any forecasting endeavor is to have an accurate and unbiased forecast. After doing the forecasting calculations, the next step is to check the error rate and forecast accuracy. Here are some formulas for calculating forecasting errors and accuracy:

3.5 Mean Absolute Deviation (MAD)

Mean Absolute Deviation (MAD) is used for this forecasting method to calculate the tracking signal. distribution of data on the tracking signal which will be used to determine whether the forecasting method can be used or not. In this study, MAD is used in the Moving Averages forecasting method. By using the willing demand data to estimate the demand that he will get in January next year, this study calculates the demand data using the4-month Moving Average forecasting method. The Mean Absolute Deviation (MAD) formula is as follows:

$$\text{Mean absolute deviation (MAD)} = \frac{\sum_{t=1}^{n} |e_t|}{n} \quad \text{....................} (11)$$

where e_t = forecast error for period t;

A_t = actual demand for period t;

n = number of periods of evaluation.

The tracking signal is used to determine if the forecast bias is within the acceptable control limits, and Tracking signal table is derived from the calculation of the Cumulative RSFE table divided by the MAD table. The tracking signal formula using the mean absolute deviation is as follows:

$$Tracking\ Signal = \frac{RSFE}{MAD} \text{..................} (13)$$

The Running sum of forecast errors (RSFE) formula using the mean absolute deviation is as follows:

$$RSFE = \sum_{t=1}^{n} e_t \text{....................................} (14)$$

where e_t = forecast error for period t;

n = number of periods of evaluation.

The RSFE is a predictor of forecasting bias. Forecast bias is defined as a forecast's tendency to be consistently higher or lower than actual demand. A positive RSFE suggests that predictions are typically lower than actual demand, perhaps resulting in stockouts. A negative RSFE indicates that projections are often greater than actual demand, which can lead to inventory carrying costs.

There is a bias problem with the forecasting approach if the tracking signal slips outside predefined control limits, and a review of how forecasts are formed is necessary. Excessive inventories or stockouts will result from a skewed projection. Some experts recommend +/- 4 for high-volume products and +/- 8 for low-volume items, while others prefer a lower limit (the smaller the better).

3.6 Mean Squared Error (MSE)

Mean Squared Error (MSE) is calculating the average squared error between the actual value and the forecast value. The Mean Squared Error method in this study is used to check the estimationof the error value in forecasting. A low Mean Squared Error value or a mean squared error value close to zero indicates that the forecasting results are in accordance with the actual data and can be used for forecasting calculations in the future period. This Mean Squared Error method is used to evaluate measurement methods with regression models or forecasting models such as Moving Average, Weighted Moving Average and Trendline Analysis. The Mean Squared Error (MSE) formula is as follows:

$$MSE = \sum_{t=1}^{n}(At - Ft)^2/\text{n} \quad \text{.............................(15)}$$

Where,

At = Actual Value of the request

Ft = Value of forecasting result

n = number of data

3.7 Mean Absolute Percentage Error (MAPE)

MAPE is calculating the absolute average error percentage (absolute). MAPE is a statistical measurement of the accuracy of the forecast (prediction) in the forecasting method used in this study, the results of the calculation of the Mean Abosolute Percentage Error (MAPE) method will provide information on how much the forecasting error is compared to the actual value of the series. The smaller the percentage error in MAPE, the more accurate the forecasting results for future needs.. The Mean Absolute Percentage Error (MAPE) formula is as follows:

$$MAPE = \sum_{t=1}^{n}|(\frac{At-Ft}{At})100/n \quad \text{... (16)}$$

Where,

At = Actual demand to t

Ft = forecasting result to t

N = the amount of forecasting data

Where there is an absolute symbol in the MAPE formula, it indicates that the negative value of the calculation result will remain positive.

4. Analysis and Discussion

The research approach used descriptive research with the aim of explaining and describing the object of research by qualitative and quantitative data. Qualitative data explained a description of the activities that company carries out in managing inventory. Quantitative data in form of salesdata, inventory data, quantity data of the arrival of goods in the company. This research has purposed to provide a clear picture of the inventory management carried out, the activities carried out by the company are recorded and evaluated. The research which was conducted at PT XYZ, especially the Storage System department, uses data for 48 months from January 2017 to Dec 2020. Based on the Pareto principle on the overall demand, we chose 5 items with high demand and contributed greatly to the company's revenue and profits (stock keeping units in Table 1, Table 2, Table 3, Table 4 and Table 5), where the product was always included in the fastmoving category consecutively duringperiod 2017 to 2020. A category products studied with consideration from these category products are products which are important, make a large contribution and require the most attention (Mulller, 2011). Quantitative data is obtained from company data in the form of Management Review (MR) data, monthly sales data, quantity data of arrival of goods and data collected which relevant from 2017 to 2020.

Table 1. Sample Data Demand in the Periods of 2017

Material Code	Description	01.2017	02.2017	03.2017	04.2017	05.2017	06.2017	07.2017	08.2017	09.2017	10.2017	11.2017	12.2017
2020PM-OR	ELEMENT RACOR 1000FH (30µ - RED)	299	366	191	326	284	229	256	680	369	288	242	215
2020TM-OR	ELEMENT RACOR 1000FH (10µ - BLUE)	583	309	303	348	358	471	427	387	212	174	358	265
2020TM-OR-A	RACOR	744	701	695	812	769	649	522	677	839	945	1.090	858
2040TM-OR	ELEMENT RACOR 900FH (10µ - BLUE)	393	563	440	1.218	604	503	663	966	391	666	1.053	610
88A13095H1	HYDRAULIC FILTER	946	646	748	708	773	864	655	975	986	804	762	649

Table 2. Sample Data Demand in the Periods of 2018

Material Code	Description	01.2018	02.2018	03.2018	04.2018	05.2018	06.2018	07.2018	08.2018	09.2018	10.2018	11.2018	12.2018
2020PM-OR	ELEMENT RACOR 1000FH (30µ - RED)	387	295	259	459	635	612	640	306	342	352	252	430
2020TM-OR	ELEMENT RACOR 1000FH (10µ - BLUE)	649	359	584	385	475	434	388	555	342	957	858	1.426
2020TM-OR-A	RACOR	598	819	614	877	1.127	779	876	917	996	1.003	1.076	1.187
2040TM-OR	ELEMENT RACOR 900FH (10µ - BLUE)	810	864	777	426	872	730	772	920	755	931	835	662
88A13095H1	HYDRAULIC FILTER	664	702	711	840	1.224	780	910	1.111	1.206	1.338	938	855

Table 3. Sample Data Demand in the Periods of 2019

Material Code	Description	01.2019	02.2019	03.2019	04.2019	05.2019	06.2019	07.2019	08.2019	09.2019	10.2019	11.2019	12.2019
2020PM-OR	ELEMENT RACOR 1000FH (30µ - RED)	541	503	655	406	675	695	1.105	670	258	405	242	128
2020TM-OR	ELEMENT RACOR 1000FH (10µ - BLUE)	1.436	3.091	2.457	2.675	2.926	2.004	2.863	1.398	229	449	853	313
2020TM-OR-A	RACOR	1.315	1.599	1.337	1.520	1.682	1.123	2.675	2.106	2.586	2.765	2.753	2.356
2040TM-OR	ELEMENT RACOR 900FH (10µ - BLUE)	454	780	864	619	833	618	1.071	1.140	718	505	661	440
88A13095H1	HYDRAULIC FILTER	1.029	983	1.203	1.037	1.033	788	1.085	1.112	1.065	1.069	808	818

Table 4. Sample Data Demand in the Periods of 2020

Material Code	Description	01.2020	02.2020	03.2020	04.2020	05.2020	06.2020	07.2020	08.2020	09.2020	10.2020	11.2020	12.2020
2020PM-OR	ELEMENT RACOR 1000FH (30µ - RED)	129	213	287	212	389	447	304	137	281	383	380	729
2020TM-OR	ELEMENT RACOR 1000FH (10µ - BLUE)	1.657	1.209	473	548	263	393	318	337	326	599	382	641
2020TM-OR-A	RACOR	1.983	2.341	1.781	3.326	2.665	2.771	2.237	2.067	2.160	2.778	2.529	2.585
2040TM-OR	ELEMENT RACOR 900FH (10µ - BLUE)	489	879	518	610	526	568	360	340	330	174	317	497
88A13095H1	HYDRAULIC FILTER	956	129	514	606	1.656	603	293	184	397	309	116	198

4.1 Calculation Results of Forecasting with the Method

Piasecki (2009) stated that the greater the number of forecast data periods, the greater the fluctuation in demand. Those estimation forecast errors have done to get the best forecasting methods. The estimation method of the forecasting accuracy level which is used in this research was Mean Absolute Deviation (MAD) and Mean Absolute Percent Error (MAPE). Referring to the formula in chapter 3, the following are the results of the estimation calculation using forecasting compared to ABC Analysis, Moving average, Simple Exponential Smoothing (SES) and Exponential Smoothing (ES) with Trend Adjustment for 5 samples of spare parts data in the following Table 5.

Table 5. Sample of Spare Part

Material Code	Description
2020PM-OR	ELEMENT RACOR 1000FH (30µ - RED)
2020TM-OR	ELEMENT RACOR 1000FH (10µ - BLUE)
2020TM-OR-A	RACOR
2040TM-OR	ELEMENT RACOR 900FH (10µ - BLUE)
88A13095H1	HYDRAULIC FILTER

1. Forecasting result with samples of Racor Elements 1000FH (30µ - RED) for the period 2017to 2020.

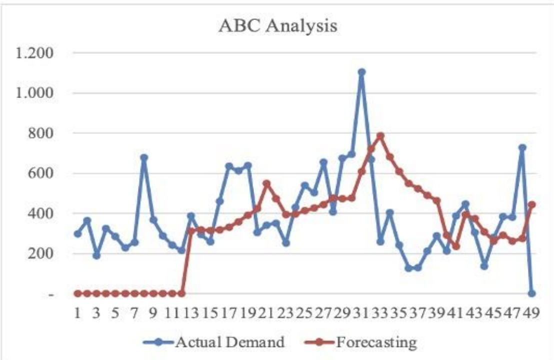

Figure 3. ABC Analysis Forecast Result

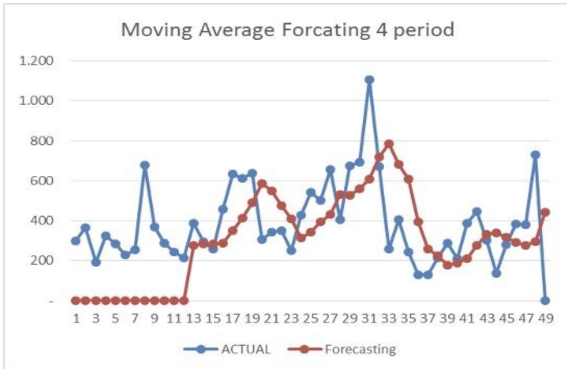

Figure 4. Moving Average Forecast Result

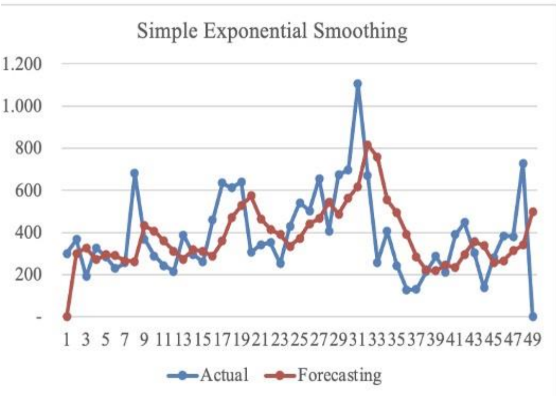

Figure 5. SES Forecast Analysis Result

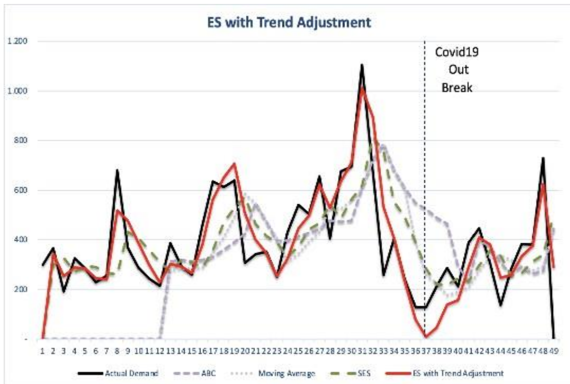

Figure 6. ES with TA Forecast Result

The results of the ABC Analysis forecasting for the ELEMENT RACOR 1000FH (30µ-RED) part obtained RSFE = 732, MAD = 86, MSE = 9.812, MAPE = 36.65. And on the Figure 3, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from ABC analysis methods.

The results of the Moving Average forecasting with a period of 4 months for the ELEMENT RACOR 1000FH (30µ - RED) part obtained RSFE = 209, MAD = 106, MSE = 15.208, MAPE = 43.26. And on the Figure 4, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Moving Average methods.

The results of the SES forecasting with α = 0,4065 for the ELEMENT RACOR 1000FH (30µ - RED) part obtained RSFE = 102, MAD = 102, MSE = 14.012, MAPE = 42.31. And on the Figure 5, the blue line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods.

The results of the ES with Trend Adjustment forecasting with α = 0,5 and β = 0,3 for the ELEMENT RACOR 1000FH (30μ - RED) part obtained RSFE = 3, MAD = 70, MSE = 8.790, MAPE = 22,13. And on the Figure 6, the black line represents real demand data, while the red line represents the forecasting data from Exponential Smoothing with Trend Adjustment methods, it shows that the ES with Adjustment forecasting method (red line) is the line closest to the actual demand line compared to the other 3 forecasting methods. In addition, the graph shows that the ES with Adjustment forecasting method (red line) can adjust the value of demand fluctuations before and after the COVID-19 pandemic.

2. Forecasting result with samples of Element Racor 1000FH (10μ - BLUE) for the period 2017 to 2020

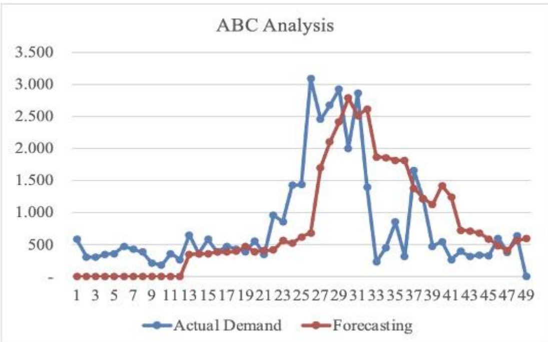

Figure 7. ABC Analysis Forecast Result

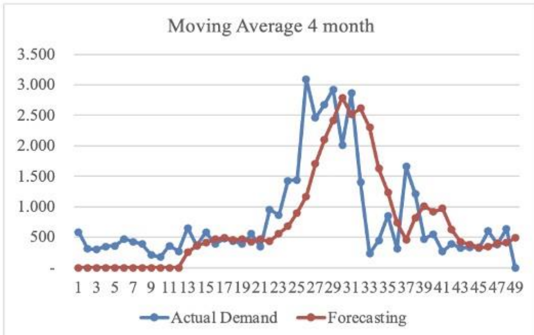

Figure 8. Moving Average Forecast Result

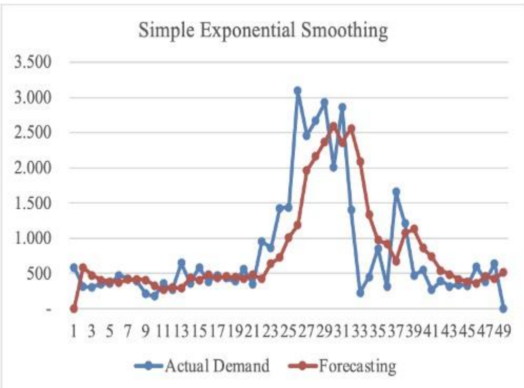

Figure 9. SES Forecast Result

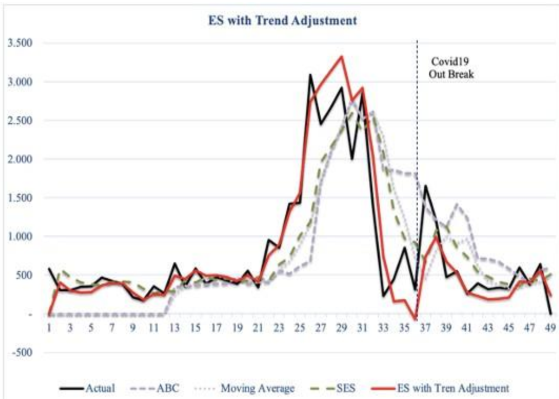

Figure 10. ES with TA Forecast Result

The results of the ABC analysis forecasting for the Element Racor 1000FH (10μ - BLUE) part obtained RSFE = 3.079, MAD = 244, MSE = 76.717, MAPE = 69.01. And on the Figure 7, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from ABC analysis methods.

The results of the Moving Average forecasting with a period of 4 months for the Element Racor 1000FH (10μ - BLUE) part obtained RSFE = 635, MAD = 108, MSE = 21.769, MAPE = 24.99. And on the Figure 8, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Moving Average methods.

The results of the Simple Exponential Smoothing (SES) forecasting with α = 0,4065 for the Element Racor1000FH (10µ - BLUE) part obtained RSFE = 170, MAD = 127, MSE = 20.256, MAPE = 31.69. And on the Figure 9, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods.

The results of the Exponential Smoothing with Trend Adjustment forecasting with α = 0,5 and β = 0,3 for the Element Racor 1000FH (10µ - BLUE) part obtained RSFE = 6, MAD = 189, MSE =83.352, MAPE = 28,14. And on the Figure 10, it can be seen that the black line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods, it shows that the Exponential Smoothing with Trend Adjustment (red line) is the line closest to the actual demand line compared to the other 3 forecasting methods. In addition, the graph shows that the Exponential Smoothing with Trend Adjustment forecasting method (red line) can adjust the value of demand fluctuations before and after the COVID-19 pandemic.

3. Forecasting result with samples of Element Racor for the period 2017 to 2020.

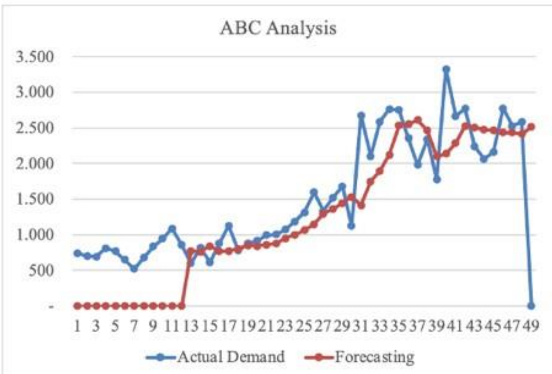

Figure 11. ABC Analysis Forecast Result

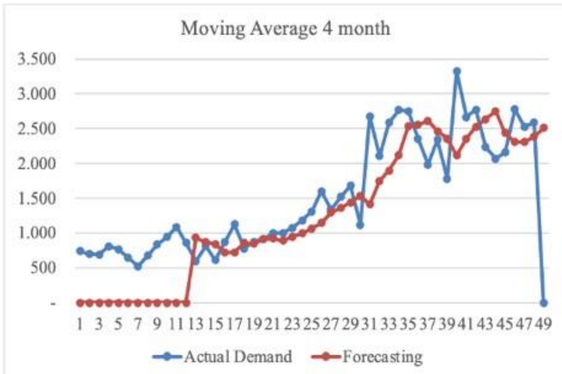

Figure 12. Moving Average Forecast Result

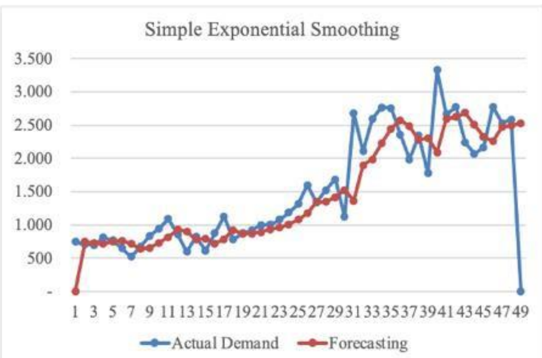

Figure 13. SES Forecast Result

Figure 14. ES with TA Forecast Result

The results of the ABC calculation. Analysis for the Element Racor part obtained RSFE = 4.832, MAD = 310, MSE = 170.692, MAPE = 16.96. And on the Figure 11, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from ABC analysis methods.

The results of the Moving Average Forcasting with a period of 4 months for the Element Racor part obtained RSFE = 4.053, MAD = 334, MSE = 194.843, MAPE = 18.83. And on the Figure 12, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Moving Average methods.

The results of the Simple Exponential Smoothing (SES) forecasting with α = 0,4065 for the Element Racor part obtained RSFE = 4.395, MAD = 254, MSE = 136.553, MAPE = 16.40. And on the Figure 13, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods.

The results of the Exponential Smoothing with Trend Adjustment forecasting with α = 0,5 and β = 0,3 for the Element Racor part obtained RSFE = 34, MAD = 123, MSE = 33.751, MAPE = 7,96. And on the Figure 14, it can be seen that the black line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods, it shows that the Exponential Smoothing with Trend Adjustment (red line) is the line closest to the actual demand line compared to the other 3 forecasting methods. In addition, the graph shows that the Exponential Smoothing with Trend Adjustment forecasting method (red line) can adjust the value of demand fluctuations before and after the COVID-19 pandemic.

4. Forecasting result with samples of Element Racor 900FH (10μ - BLUE) for the period 2017 to 2020.

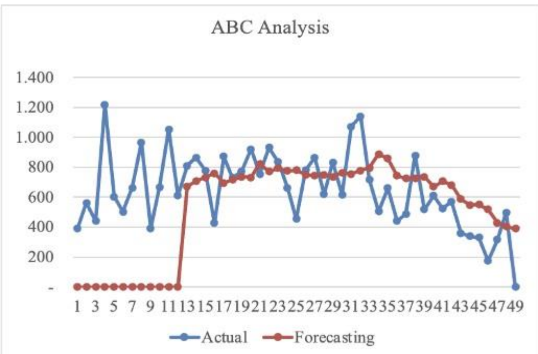

Figure 15. ABC Analysis Forecast Result

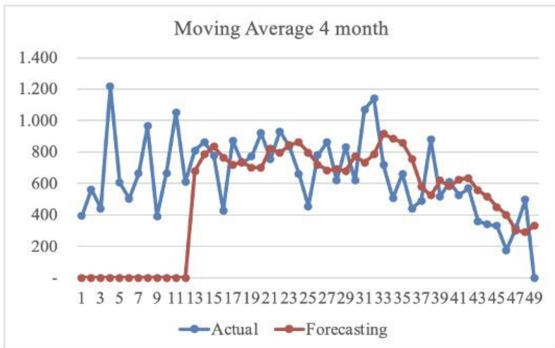

Figure 16. Moving Average Forecast Result

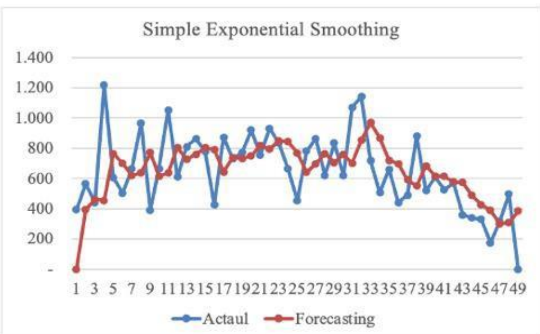

Figure 17. SES Forecast Result

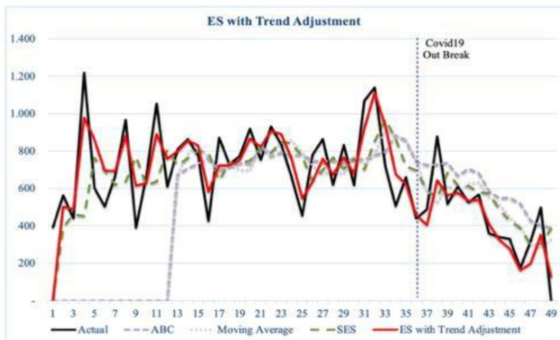

Figure 18. ES with TA Forecast Result

The results of the ABC Analysis forecasting for the Element Racor 900FH (10µ - BLUE) part obtained RSFE = 1.874, MAD = 170, MSE = 39.244, MAPE = 33.96. And on the Figure 15, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from ABC Analysis methods.

The results of the Moving Average forecasting with a period of 4 months for the Racor 900FH (10µ - BLUE) part obtained RSFE = 926, MAD = 164, MSE = 38.526, MAPE = 29.89. And on the Figure 16, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Moving Average methods.

The results of the Simple Exponential Smoothing (SES) forecasting with α = 0,4065 for the Racor 900FH (10µ - BLUE) part obtained RSFE = 21, MAD = 178, MSE = 51.874, MAPE = 29.88. And on the Figure 17, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods.

The results of the Exponential Smoothing with Trend Adjustment forecasting with α = 0,5 and β = 0,3 for the Racor 900FH (10µ - BLUE) part obtained RSFE = 1, MAD = 89, MSE = 12.895, MAPE = 14,56. And on the Figure 18, it can be seen that the black line represents real demand data, while the red line represents the forecasting data from Exponential Smoothing with Trend Adjustment methods, it shows that the Exponential Smoothing with Trend Adjustment forecasting method (red line) is the line closest to the actual demand line compared to the other 3 forecasting methods. In addition, the graph shows that the Exponential Smoothing with Trend Adjustment forecasting method (red line) can adjust the value of demand fluctuations before and after the COVID-19 pandemic.

5. Forecasting result with samples of Element Hydraulic Filter for the period 2017 to 2020.

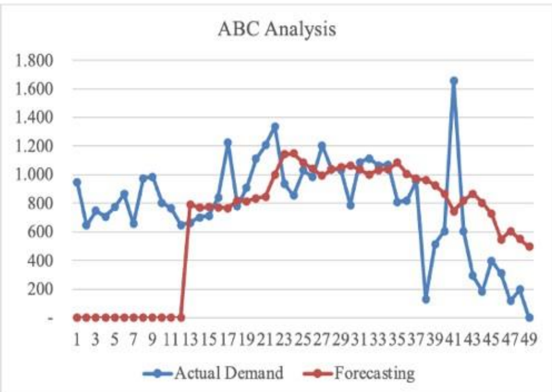

Figure 19. ABC Analysis Forecast Result

Figure 20. Moving Average Forecast Result

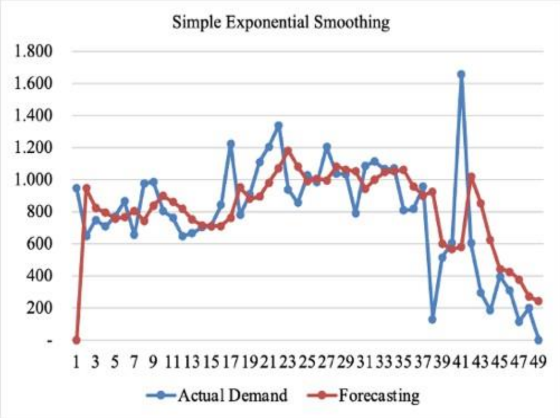

Figure 21. SES Forecast Result

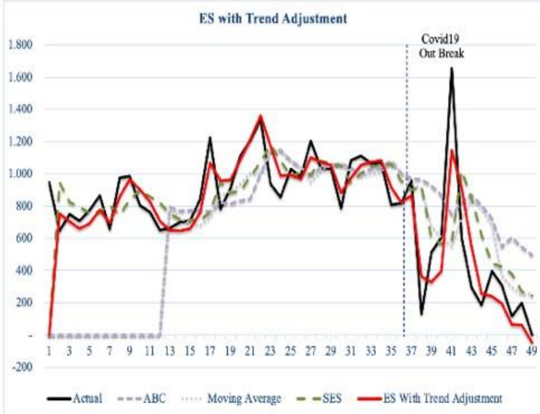

Figure 22. ES with TA Forecast Result

The results of the ABC Analysis forecasting for the Element Hydraulic Filter part obtained RSFE = 3.063, MAD = 249, MSE = 111.184, MAPE = 70.33. And on the Figure 19, it can be seen that the blue line represents real demand data, while the red line represents the forecasting data from ABC analysis methods.

The results of the Moving Average Forecasting with a period of 4 months for the Element Hydraulic Filter part obtained RSFE = 1.330, MAD = 210, MSE = 99.034, MAPE = 52.50. And on the Figure 20, the blue line represents real demand data, while the red line represents the forecasting data from Moving Average methods.

The results of the SES forecasting with α = 0,4065 for the Element Hydraulic Filter part obtained RSFE = 1.733, MAD = 187, MSE = 76.565, MAPE = 43.76. And on the Figure 21, the blue line represents real demand data, while the red line represents the forecasting data from Simple Exponential Smoothing methods.

The results of the ES with Trend Adjustment forecasting with α = 0,5 and β = 0,3 for the Element Hydraulic Filter part obtained RSFE = 9 MAD = 101, MSE =18.872, MAPE = 19,91. And on the Figure 22, it can be seen that the black line represents real demand data, while the red line represents the forecasting data from Exponential Smoothing with Trend Adjustment methods, it shows that the Exponential Smoothing with Trend Adjustment forecasting method (red line) is the line closest to the actual demand line compared to the other 3 forecasting methods. In addition, the graph shows that the Exponential Smoothing with Trend Adjustment forecasting method (red line) can adjust the value of demand fluctuations before and after the COVID-19 pandemic.

4.2 The Forecasting Accuracy

After performing forecasting calculations using the four models above for each type of material number. The next step is to calculate the error rate and forecasting accuracy for each type of material number and compare it from the four forecasting methods to see a smaller error rate (MAPE) and a Tracking Signal / bias value, where the closer to 0 the higher the level of accuracy.

Comparative analysis using the four methods of demand for spare parts can be seen as follows:

1. P/N : ELEMENT RACOR 1000FH (30µ - RED)

The results of the comparison of the four forecasting methods show that: by using the forecasting Exponential Smoothing with Trend Adjustment method, it provides a Tracking Signal / bias value of + 0.05, where if the resulting value is closer to 0, the accuracy level is higher and will be the best method compared to the other 3 forecasting models. The forecasting Exponential Smoothing with Trend Adjustment method gives a MAPE value = 22, where the smaller the error value, the better the forecasting accuracy or the best results comparedto the other 3 forecasting models.

2. P/N: ELEMENT RACOR 1000FH (10µ - BLUE)

The results of the comparison of the four forecasting methods show that: by using the forecasting ES with Trend Adjustment method, it provides a Tracking Signal / bias value of + 0.03, where if the resulting value is closer to 0, the accuracy level is higher and will be the best method compared to the other 3 forecasting models. The forecasting Exponential Smoothing with Trend Adjustment method gives a MAPE value = 28, where the smaller the error value, the better the forecasting accuracy or the best results compared to the other 3 forecasting models.

3. P/N RACOR

The results of the comparison of the four forecasting methods show that: by using the Forecasting ES with Adjustment method, it provides a Tracking Signal / bias value of - 0,28, where if the resulting value is closer to 0, the accuracy level is higher and will be the best method compared to the other 3 forecasting models. The Forecasting ES with Adjustment method gives a MAPE value = 8, where the smaller the error value, the better the forecasting accuracy or the best results compared to the other 3 forecasting models.

4. P/N: ELEMENT RACOR 900FH (10µ - BLUE)

The results of the comparison of the four forecasting methods show that: by using the Forecasting ES with Adjustment method, it provides a Tracking Signal / bias value of + 0,02, where if the resulting value is closer to 0, the accuracy level is higher and will be the best method compared to the other 3 forecasting models. The Forecasting ES with Adjustment method gives a MAPE value = 15, where the smaller the error value, the better the forecasting accuracy or the best results compared to the other 3 forecasting models.

5. P/N : Hydraulic Filter (OLD PN 600-211-1231A)

The results of the comparison of the four forecasting show that: by using the Forecasting ES with Adjustment method, it provides a Tracking Signal / bias value of + 0,09, where if the resulting value is closer to 0, the accuracy level is higher and will be the best method compared to the other 3 forecasting models. The Forecasting ES with Adjustment method gives a MAPE value = 20, where the smaller the error value, the better the forecasting accuracy or the best results compared to the other 3 forecasting models.

Table 6. Result of Comparison MAPE and Tracking Signal

			MAPE				Tracking Signal			
No	P/N	Description	ABC Analysis	Moving Average (4 mth)	Simple Exponential Smoothing (SES)	Exponential Smoothing with Trend Adjustment	ABC Analysis	Moving Average (4 mth)	Simple Exponential Smoothing (SES)	Exponential Smoothing with Trend Adjustment
1	2020PM-OR	ELEMENT RACOR 1000FH (30µ - RED)	61,63	50,74	42,92	22,13	-1,46	3,68	3,38	0,05
2	2020TM-OR	ELEMENT RACOR 1000FH (10µ - BLUE)	94,92	75,95	62,52	28,14	-5,55	1,32	-0,47	0,03
3	2020TM-OR-A	RACOR	16,96	18,83	16,40	7,96	15,77	12,12	17,31	-0,28
4	2040TM-OR	ELEMENT RACOR 900FH (10µ - BLUE)	33,96	29,89	29,88	14,56	-11,01	-5,66	-0,12	0,02
5	88A13095H1	HYDRAULIC FILTER	70,33	52,50	43,76	19,91	-12,32	-6,35	-9,28	0,09
AVERAGE			55,56	45,58	39,10	18,54	(2,91)	1,02	2,16	(0,02)

The following Table 6 is the result of forecasting calculations for each forecasting method on a sample of five materials. The results of the forecasting calculations depicted in the previous figure, the researchers conducted testing to determine the error and the level of accuracy of the forecasting results from each forecasting method used, the table shows that Exponential Smoothing with Trend adjustment produces the lowest MAPE value for each Part Number tested and have the lowest average MAPE value of 18.54 compared to the other three forecasting methods. The level of accuracy generated by looking at the Tracking Signal/ bias value where Exponential Smoothing with Trend Adjustment produces a tracking signal/ bias value an average - 0.02, close to 0 compared to the other three forecasting methods is the best result. Exponential smoothing is one of the most widely used forecasting techniques due to its simplicity and low data requirements. Like other time series models, this model is best suited for data with few trends or seasonal trends. With the number close to 1, the prediction of exponential smoothing places a higher focus on the most recent data, resulting in a significant reduction in the error in the forecast. As a result, a high number indicates that the model is more responsive to recent changes in demand.

5. Conclusion and Recommendation

5.1 Conclusion

The conclusion of this study which initially compared the four forecasting methods, namely the ABC analysis (current forecasting method used by the company), Moving Average, Simple Exponential Smoothing and Exponential Smoothing (ES) with Trend Adjustment using 5 samples of spare parts data to forecast the demand for spare parts at PT XYZ uses demand data for the 2017-2020 period to forecast demand in 2021.

The results of the analysis of ABC Analysis, Moving Average, SES and Exponential Smoothing with Trend Adjustment, show ES with Trend Adjustment that produces the lowest MAPE value for each Part Number tested and have the lowest average MAPE value of 18.54 so has a smaller prediction error than the other three.

The results of accuracy generated by looking at the Tracking Signal/ bias value, the forecasting ES with Trend Adjustment method gives the value of the Tracking Signal/bias value generated an average of - 0.02 close to 0, the level of accuracy is higher and will be the best method compared to the others three.

From the Figure 6, Figure 10, Figure 14, Figure 18 and Figure 22, it can be seen that the ES with Trend Adjustment forecasting method (red line) are the line closest to the actual demand line (black line) and can adjust quickly and accurately to fluctuations in demand before and after COVID-19 pandemic. The results also show that peak demand in the 2019 period before the COVID- 19 pandemic cannot be accurately predicted by the others three forecasting methods, so it can cause procurement delays which result in fines that must be paid by the company.

5.2 Recommendations

In addition to having a better forecasting method, the company management of PT XYZ must also pay attention to the following recommendations: First, companies should apply the level of forecasting error (MAPE) and level of accuracy (Tracking signal/bias value) as an integral part of using the Exponential Smoothing with Trend Adjustment method to get the best forecasting results. Second, companies should have an inventory policy that determines inventory levels to accommodate uncertain demand and prevent stock outs.

5.3 Research Limitation

So that the company does not make the wrong decision on a better forecasting method, the company management of PT XYZ must also pay attention to the limitation: "this research does not cover forecasting methods for slow moving and non-moving parts, and further studies should be carried".

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