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Forecasting Optimalization in Spare Part Inventory Applications on XYZ Temanggung Outlet Ltd.

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ABSTRACT
XYZ Magelang Branch Ltd is a company engaged in the automotive sector, which supported by three outlets. The name of the outlet are Temanggung Outlet, Purworejo Outlet, and Kebumen Outlet. The Temanggung Outlet is one of the outlet with the highest number of services compared to the others. The impact of having the highest number of services is that the demand for spare parts is also the highest compared to the other outlets. To overcome the demand for spare parts at the Temanggung Outlet, an inventory application is needed to manage spare parts with the implementation of forecasting to determine the stock of spare parts for the upcoming period. In this research, the forecasting calculation is carried out by utilizing the historical calculation of the outgoing transaction data in the inventory application. The data obtained from the sales transaction report is in the form of spare parts sales with a data quantity of 30 items, selected from the top 30 spare parts sales. The calculation process using the Single Moving Average (SMA) forecasting is validated using Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE). In this research manuscript, SMA has MAPE error with range 0% up to 62.069% compared to the conventional method, which has range 16% up to 83%.

Keywords: Forecasting, Single moving average, Spare part Inventory, MAD, MAPE

INTRODUCTION

As time passes, communication methods are rapidly evolving through the use of technology that combines information technology and communication technology to effectively and efficiently support a company's business processes (Permana, 2021). Planning spare parts stock to meet market demand is a key aspect of effective inventory management. Inventory management is a component of a company's supply chain management that aims to plan, implement, and control the flow or pattern of storing goods, services, and related information from the point of origin to the point of consumption to meet customer needs effectively and efficiently (Toorajipour et al., 2021).

XYZ Temanggung Outlet Ltd is a company operating in the automotive industry, which includes selling cars through cash or credit, providing general and body services, as well as selling spare parts. The business division of XYZ Temanggung Outlet Ltd comprises the Vehicle Sales Division, Vehicle Service Division, Body Repair and Paint Division, and Spare Parts Division, which is responsible for managing the inventory of spare parts (Giva & Muharam, 2017).

In terms of the types of spare parts managed, there are two categories, namely moving parts and non-moving parts. Moving parts are spare parts that need to be stocked at all times due to demand. To manage moving parts effectively, it is necessary to maintain a replacement stock. Moving parts are generally used for regular servicing. Meanwhile, non-moving parts are spare parts that are not stocked because they are rarely in demand. Generally, non-moving parts are body parts (Giva & Muharam, 2017).

XYZ Temanggung Outlet Ltd operates as a car dealership with a market area in the Kedu Residency as well as the largest market area in Central Java. This necessitates the need for sub-branches or outlets to manage the business effectively. The Spare Parts Division is also responsible for managing the business at these outlets, particularly in the spare parts section. The outlets that have been established are located in Kebumen, Purworejo, and Temanggung. But the main focus of this research paper is on the Temanggung outlet.

In managing the inventory of the outlet, there are three issues. The first problem is the distance between the XYZ Temanggung Outlet Ltd dealership and the outlet, which results in difficulties in monitoring spare parts inventory in real-time. The second problem is the lack of an inventory application to aid in spare parts management, which affects the difficulty in monitoring the inflow and outflow of spare parts. The third problem is the existence of shortages and excess stock of spare parts. These three issues are experienced by three outlets in the Kedu Residency. However, for the purpose of this research, the observed outlet is the Temanggung Outlet. The hope is that if the problem at the Temanggung Outlet is solved, then the issues at the other two outlets will also be resolved (Giva & Muharam, 2017).

To address the first and second issues, XYZ Temanggung Outlet Ltd has taken steps to build an online spare parts inventory application at the outlet to monitor the inflow

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and outflow of spare parts in real-time. The solution for the third problem is by implementing forecasting optimization on the spare parts inventory application at the outlet to determine the amount of spare parts for the upcoming period.

Based on these problems, the company requires an inventory application with optimization in the form of sales data analysis of spare parts by conducting forecasting. The next step involves displaying the analysis results in a graph, along with the forecasted calculation values, which will serve as the basis for determining the stock of parts in the upcoming period. Moreover, the inventory application can be accessed online.

The forecasting model of choice for analyzing spare parts sales data is the SMA s method, among various other forecasting methods. Single Moving Average (SMA) method has the advantage of functioning as a forecasting tool to calculate the average sales of spare parts over a certain period, which will be continuously calculated based on the movement of data. This method is highly efficient, easy to use, and effective in its calculation process, as it does not require weighting of each data point (Wijaya & Gantini, 2019).

After performing forecasting, an evaluation will be conducted to determine the level of forecasting error. The accuracy level of the forecasting method is tested by using the Mean Absolute Deviation (MAD) and Mean Absolute Percentage error (MAPE) methods. MAD is a method for evaluating forecasting accuracy by using a simple calculation of the total error, based on the average error obtained. (Syafwan et al., 2021). The MAPE is a method for evaluating the accuracy of a forecast by calculating the absolute error for each period and then dividing it by the value obtained from the corresponding observed period (Syafwan et al., 2021).

Based on the above problem description, it is evident that XYZ Temanggung Outlet Ltd's requires an inventory spare part management application with optimized forecasting. The optimization required in the inventory management application of XYZ Temanggung Outlet Ltd. It is the form of forecasting optimization through sales data analysis of spare parts, with outputs in the form of graphs and forecasting analysis calculations.

Based on the discussion above, an implementation of a spare parts inventory management application will be conducted to manage spare parts stock, with the optimization of forecasting on the inventory system to determine the stock of spare parts in the upcoming period. This study used the sales data of spare parts from the XYZ Temanggung Outlet Ltd. This data collected from spare parts sales report, specifically from the XYZ Temanggung Outlet Ltd.

LITERATURE REVIEW

- Inventory Management

Inventory management is the process of managing inventory or raw materials with the goal of ensuring that they remain in a well-maintained condition. The application of inventory management plays a crucial role in organizations operating in the retail industry. The objective of inventory management is to ensure the availability of goods with maximum service levels and minimum production costs (MacAs et al., 2021).

- Time Series Analysis

Time series analysis is a method that utilizes statistical and mathematical equations based on past period data to make predictions for future period(Wijaya & Gantini, 2019).

Time Series Analysis has been widely used in various fields of science, including vegetation analysis, engineering, hydrology, finance, medicine, ecology, renewable energy, chemistry, and history (Rhif et al., 2019)

- Forecasting

Forecasting is a necessary tool for effective and efficient planning, especially in the field of economics, as it is part of the decision support system (Noor et al., 2019).

Forecasting is widely implemented in the business field, as it serves as a basis for making decisions in the future. In the marketing field, forecasting can be used to help observe the level of product sales, to observe the level of product distribution, thus assisting the company's management in determining what kind of marketing strategies are needed for the future (Noor et al., 2019).

- Single Moving Average (SMA)

The foundation of the SMA method is the Moving Average, which summarizes all the data changes within a period and is often used for forecasting based on time series analysis (Su et al., 2022).

The SMA is a forecasting method that involves observing a set of values, calculating the average, and using that to determine the forecasted value for future periods(Pataropura & Sabatino, 2020). SMA is a forecasting method that involves observing a set of values, calculating the average, and using it to determine the forecasted value for the upcoming period. Unlike other methods, SMA does not apply weighting to each data

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point, but it is still considered effective and efficient in calculating market trends (Noor et al., 2019).

SMA has the following specific characteristics:

(1) SMA requires historical data over a certain period of time to calculate a forecast (Noor et al., 2019)
(2) The further the moving average period, the more the smoothing effect is detected, and the better the moving average result (Noor et al., 2019).

The formula for SMA is as follows:

$$Ft + 1 = \frac{Xt+Xt-1+\cdots Xt-n+1}{n} \qquad (1)$$

With:
Ft + 1 = the prediction for period t+1
X1 = the data for period t
n = the period of the moving average

- Mean Absosulte Deviation (MAD)

MAD is a method for evaluating the accuracy of a forecasting method by using the total of absolute errors. MAD measures the accuracy of predictions based on the average error obtained (Krisma et al., 2019).

The following is the formula for MAD:

$$MAD = \frac{\sum|At-Ft|}{n} \qquad (2)$$

With:
At = Actual demand in period t
Ft = Forecasting at period t
N = the specified number of periods

- Mean Absolute Precentage Error (MAPE)

The MAPE error is calculated by finding the average value of the absolute difference between the values obtained from the forecasting calculation and the actual value, which is then expressed as a percentage of the actual value (Reicita, 2020)(Syafwan et al., 2021).
Formula of PE

$$PE = (\frac{XT-FT}{Xt}) \qquad (3)$$

Formula of MAPE

$$\sum_{t=1}^{n} = 1\frac{PEt}{n} \qquad (4)$$

With:

n = time periode value
Xt = actual value
Ft = value of forcasting at periode t

- Dataset

The dataset was obtained from the sales data of the Temanggung outlet of the spare parts sub-division of PT.XYZ. This dataset contains 30 data items of vehicle parts, including the sales month, part number, part name, and monthly sales quantity. In this research, to ensure that the dataset is suitable for the forecasting data mining method used, the data processing from raw data to a dataset follows the rules set out in the Knowledge Discovery Data process. conventional method forecasting can be seen in the table 1 and table 2 below.

Table 1 Sales report from Temanggung outlet spare parts in 2019

	PART NUMBER	PART NAME	PERIOD T			
			SEPT	OKT	NOV	DEC
1	08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67
2	08880-83575	TMO SYN 10-40 GASOLINE 1LT	48	42	72	64
3	08880-83352	TMO SYN 15-40 DIESEL 4LT	36	24	32	48
4	08880-83351	TMO SYN 15-40 DIESEL 1LT	48	27	72	48
5	08885-80929	TMO TRANS OIL	24	12	32	32
6	08885-80930	TMO DIFF OIL	27	12	36	48
7	15601-BZ030	OF AGYA/CALYA/GRAND AVANZA	32	32	64	32
8	15601-YZZT1	OF AVANZA LAMA / RUSH	16	64	16	48
9	90915-YZZD2-82	OF INNOVA / FORTUNER	32	17	40	32
10	90915-YZZE1-82	OF YARIS / ALTIS	8	4	16	5
11	17801-BZ100	AIR FILTER AGYA	1	5	1	4
12	17801-BZ050	AIR FILTER AVANZA	4	3	3	9
13	17801-BZ150	AIR FILTER GRAND NEW AVANZA	4	5	5	8
14	17801-YZZA1	AIR FILTER INNOVA, FORTUNER	4	6	4	3
15	9004A-91065	SPARK PLUG AGYA	6	4	12	9
16	9004A-91016	SPARK PLUG AVANZA NON VVTI	8	8	4	4
17	9004A-91032	SPARK PLUG AVANZA VVTI, RUSH	8	16	20	16
18	90919-T1004	SPARK PLUG INNOVA, FORTUNER, HILUX	24	8	12	16
19	90919-T1002	SPARK PLUG YARIS	8	8	8	12
20	88568-BZ040	FILTER AC AVANZA F601, F651	3	3	4	4
21	88568-BZ050	FILTER AC AGYA, GRANDNEW AVZ	3	5	3	8
22	85212-BZ210	WIPPER BLADE RH	1	1	4	8
23	85222-BZ220	WIPER BLADE LH	1	1	4	8
24	90049-51125	BULB HEADLAMP ORI	3	6	3	5
25	90049-51185	BULB H-16 (FOGLAMP AVZ) ORI	5	3	4	3
26	99132-21230-76	BULB REM	4	2	3	2
27	23390-YZZA1-82	FUEL FILTER GD EG	6	6	8	8
28	23390-0L070-82	FUEL FILTER KD EG	2	2	2	3
29	04465-BZ170	BRAKE PAD AVANZA	11	7	6	11
30	04465-0K430	BRAKE PAD INNOVA REBORN	3	2	2	4

Table 2 Sales report from Temanggung outlet spare parts in 2020

NO	PART NUMBER	PART NAME	PERIOD T			
			SEPT	OKT	NOV	DEC
1	01088-BRAKE	BRAKE CLEANER	30	35	36	42
2	01088-CABIN	CABIN CLEANER	18	18	23	30
3	01088-FLUSH	ENGINE FLUSH	26	14	21	26
4	01088-INJCT	INJECTOR CLEANER FOAM	7	11	5	8
5	01088-INCTDIS	INJECTOR DIESEL	8	7	6	13
6	02088-INJCT	INJECTOR LIQUID	16	9	14	14
7	04465-BZ170	BRAKEPAD AVANZA	8	9	8	9
8	08808-80060	WIPPER FLUID	7	11	15	29
9	08880-83351	TMO SYN 15-40 DIESEL 1LT	12	23	12	23
10	08880-83352	TMO SYN 15-40 DIESEL 4LT	16	18	16	25
11	08880-83575	TMO SYN 10-40 GASOLINE 1LT	26	19	21	33
12	08880-83576	TMO SYN 10-40 GASOLINE 4LT	46	39	43	52
13	08885-80929	TMO TRANS OIL	14	17	23	20
14	08885-80930	TMO DIFF OIL	20	24	31	33
15	12157-10010	GASKET DIFF	22	24	28	32
16	15601-BZ030	OF AVANZA/AGYA	28	15	17	28
17	15601-YZZT1	OF AVANZA RUSH	9	15	12	14
18	23390-0L070-82	FUEL FILTER GD EG	5	2	1	4
19	23390-YZZA1-82	FUEL FILTER KD EG	2	6	3	5
20	31210-BZ021	COVER CLUTH	2	1	4	3
21	31250-BZ130	DISC CLUTH	2	1	4	3
22	5210	BATTERY LIQUID	21	20	25	31
23	85212-BZ210	WIPPER BLADE RH	3	4	6	11
24	85222-BZ220	WIPER BLADE LH	3	4	6	11
25	9004A-91032	SPARK PLUG AVANZA NON VVTI	20	32	8	28
26	9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6
27	90430-GASKET	GASKET ENGINE	59	53	53	79
28	90430-GEAR-A	GASKET TRANS SMALL	8	10	18	16
29	90430-GEAR-B	GASKET TRANS BIG	10	6	8	6

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30	90915-YZZD2-82	OF INNOVA, FORTUNER	17	17	17	26

METHOD

The first research method carried out is literature study, which is a theoretical review of inventory application. Secondly, data collection was carried out through field studies and interviews. Thirdly, analyze primary and secondary data obtained from fieldwork and interviews. The fourth stage involves designing an application based on the System Requirement Specification (SRS) document. The fifth step involves implementing the inventory application with forecasting optimization. The research method mapping can be seen in the Figure 1 below.

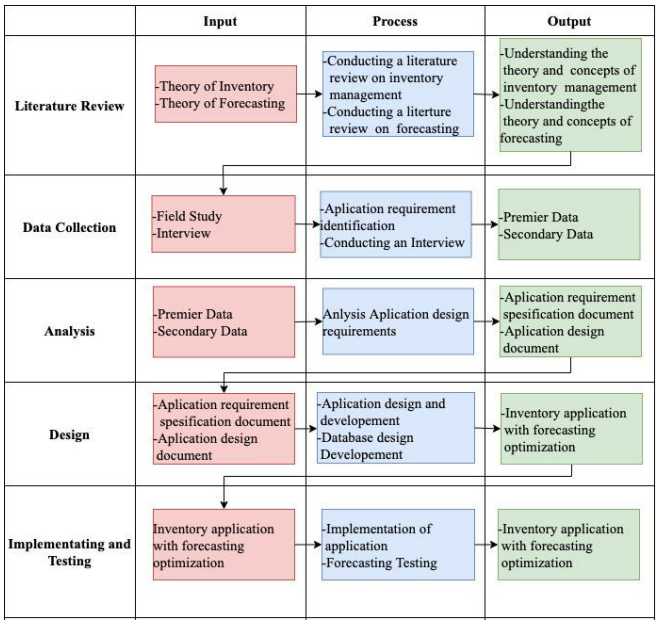

Figure 1 Research Method

RESULT AND DISCUSSION

This discussion will involve a comparative analysis between two forecasting methods - conventional forecasting without equation formulas and the SMA forecasting calculation. The analysis will focus on the samples with the lowest and highest MAPE errors to facilitate the comparison.

- Forecasting

(1) Forecasting use conventional method

Prior to implementing the SMA forecasting method at this stage, spare part stock predictions were based on the staff's habits using spare part sales reports from 2019, before the inventory system was established. The results of the conventional method forecasting can be seen in the table 3 below.

Table 3 Forecasting Results with Conventional Methods

NO	PART NUMBER	PART NAME	PERIOD T				FT (DEC)
			SEPT	OKT	NOV	DEC	
1	08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67	80
2	08880-83575	TMO SYN 10-40 GASOLINE 1LT	48	42	72	64	48
3	08880-83352	TMO SYN 15-40 DIESEL 4LT	36	24	32	48	28
4	08880-83351	TMO SYN 15-40 DIESEL 1LT	48	27	72	48	36
5	08885-80929	TMO TRANS OIL	24	12	32	32	24
6	08885-80930	TMO DIFF OIL	27	12	36	48	28
7	15601-BZ030	OF AGYA/CALYA/GRAND AVANZA	32	32	64	32	40
8	15601-YZZT1	OF AVANZA LAMA / RUSH	16	64	16	48	40
9	90915-YZZD2-82	OF INNOVA / FORTUNER	32	17	40	32	20
10	90915-YZZE1-82	OF YARIS / ALTIS	8	4	16	5	8
11	17801-BZ100	AIR FILTER AGYA	1	5	1	4	3
12	17801-BZ050	AIR FILTER AVANZA	4	3	3	9	5
13	17801-BZ150	AIR FILTER GRAND NEW AVANZA	4	5	5	8	5
14	17801-YZZA1	AIR FILTER INNOVA, FORTUNER	4	6	4	3	2
15	9004A-91065	SPARK PLUG AGYA	6	4	12	9	6
16	9004A-91016	SPARK PLUG AVANZA NON VVTI	8	8	4	4	8
17	9004A-91032	SPARK PLUG AVANZA VVTI, RUSH	8	16	20	16	20
18	90919-T1004	SPARK PLUG INNOVA, FORTUNER, HILUX	24	8	12	16	10
19	90919-T1002	SPARK PLUG YARIS	8	8	8	12	8
20	88568-BZ040	FILTER AC AVANZA F601, F651	3	3	4	4	8
21	88568-BZ050	FILTER AC AGYA, GRANDNEW AVZ	3	5	3	8	6
22	85212-BZ210	WIPPER BLADE RH	1	1	4	8	5
23	85222-BZ220	WIPER BLADE LH	1	1	4	8	5
24	90049-51125	BULB HEADLAMP ORI	3	6	3	5	7
25	90049-51185	BULB H-16 (FOGLAMP AVZ) ORI	5	3	4	3	5
26	99132-21230-76	BULB REM	4	2	3	2	5
27	23390-YZZA1-82	FUEL FILTER GD EG	6	6	8	8	5
28	23390-0L070-82	FUEL FILTER KD EG	2	2	2	3	2
29	04465-BZ170	BRAKE PAD AVANZA	11	7	6	11	6
30	04465-0K430	BRAKE PAD INNOVA REBORN	3	2	2	4	8

(2) Forecasting SMA Method

This stage applies the SMA forecasting method to one of the spare part samples, namely the spare part with part number 9004A-91065 in the dataset. The data used is shown in Table 4 below.

Table 4 Forecasting with the SMA Method

PART NUMBER	PART NAME	PERIOD T			
		SEPT	OKT	NOV	DEC
9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6

Method

$$Ft+1 = \frac{Xt+Xt-1+\cdots Xt-n+1}{n} \quad (5)$$

$$Ft+1 = \frac{9+6+3}{3} = 6 \quad (6)$$

The forecasted quantity for part number 9004A-91065 is 6 pieces, as calculated above. When this value is implemented in the table, it appears as shown in Table 5 below:

Table 5 Forecasting Implementation on Sample Dataset

PART NUMBER	PART NAME	PERIOD T				FT
		SEPT	OKT	NOV	DEC	
9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6	6,000

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The results of applying the SMA forecasting method to 30 datasets are presented in Table 6 below:

Table 6 Forecasting Results with the SMA Method

NO	PART NUMBER	PART NAME	PERIOD T				FT
			SEPT	OKT	NOV	DEC	
1	01088-BRAKE	BRAKE CLEANER	30	35	36	42	33,667
2	01088-CABIN	CABIN CLEANER	18	18	23	30	19,667
3	01088-FLUSH	ENGINE FLUSH	26	14	21	26	20,333
4	01088-INJCT	INJECTOR CLEANER FOAM	7	11	5	8	7,667
5	01088-INCTDIS	INJECTOR DIESEL	8	7	6	13	7,000
6	02088-INJCT	INJECTOR LIQUID	16	9	14	14	13,000
7	04465-BZ170	BRAKEPAD AVANZA	8	9	8	9	8,333
8	08808-80060	WIPPER FLUID	7	11	15	29	11,000
9	08880-83351	TMO SYN 15-40 DIESEL 1LT	12	23	12	23	15,667
10	08880-83352	TMO SYN 15-40 DIESEL 4LT	16	18	16	25	16,667
11	08880-83575	TMO SYN 10-40 GASOLINE 1LT	26	19	21	33	22,000
12	08880-83576	TMO SYN 10-40 GASOLINE 4LT	46	39	43	52	42,667
13	08885-80929	TMO TRANS OIL	14	17	23	20	18,000
14	08885-80930	TMO DIFF OIL	20	24	31	33	25,000
15	12157-10010	GASKET DIFF	22	24	28	32	24,667
16	15601-BZ030	OF AVANZA/AGYA	28	15	17	28	20,000
17	15601-YZZT1	OF AVANZA RUSH	9	15	12	14	12,000
18	23390-0L070-82	FUEL FILTER GD EG	5	2	1	4	2,667
19	23390-YZZA1-82	FUEL FILTER KD EG	2	6	3	5	3,667
20	31210-BZ021	COVER CLUTH	2	1	4	3	2,333
21	31250-BZ130	DISC CLUTH	2	1	4	3	2,333
22	5210	BATTERY LIQUID	21	20	25	31	22,000
23	85212-BZ210	WIPPER BLADE RH	3	4	6	11	4,333
24	85222-BZ220	WIPER BLADE LH	3	4	6	11	4,333
25	9004A-91032	SPARK PLUG AVANZA NON VVTI	20	32	8	28	20,000
26	9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6	6,000
27	90430-GASKET	GASKET ENGINE	59	53	53	79	55,000
28	90430-GEAR-A	GASKET TRANS SMALL	8	10	18	16	12,000
29	90430-GEAR-B	GASKET TRANS BIG	10	6	8	6	8,000
30	90915-YZZD2-82	OF INNOVA, FORTUNER	17	17	17	26	17,000

- MAD Analysis

(1) MAD in conventional forecasting method.

At this stage, one part number is selected from 30 datasets, and the chosen part number is 08880-83576. The data used is shown in Table 7 below:

Table 7 ample Forecasting with Conventional Methods

PART NUMBER	PART NAME	PERIOD T				FT (DEC)
		SEPT	OKT	NOV	DEC	
08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67	80

$$MAD = \frac{\sum|At-Ft|}{n} \quad (7)$$

$$At_{(DEC)} = 80 \quad (8)$$

$$Ft_{(DEC)} = 67 \quad (9)$$

$$MAD = \frac{\sum|80-67|}{1} = 13 \quad (10)$$

Based on the MAD calculation, the conventional forecasting method resulted in a forecast of 6 pieces for part number 08880-83576. When implemented in the table, the forecasting result can be seen in Table 8 in attachment.

Table 8 MAD Validation on Forecasting with Conventional Methods

PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD
		SEPT	OKT	NOV	DEC		
08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67	80	13

When implemented on the following 30 data of conventional forecasting method, the results of the MAD calculation can be seen in the Table 9 below.

Table 9 MAD Validation Implementation on Conventional Forecasting Dataset method

NO	PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD
			SEPT	OKT	NOV	DEC		
1	01088-BRAKE	BRAKE CLEANER	64	72	48	67	80	13
2	01088-CABIN	CABIN CLEANER	48	42	72	64	48	16
3	01088-FLUSH	ENGINE FLUSH	36	24	32	48	28	20
4	01088-INJCT	INJECTOR CLEANER FOAM	48	27	72	48	36	12
5	01088-INCTDIS	INJECTOR DIESEL	24	12	32	32	24	8
6	02088-INJCT	INJECTOR LIQUID	27	12	36	48	28	20
7	04465-BZ170	BRAKEPAD AVANZA	32	32	64	32	40	8
8	08808-80060	WIPPER FLUID	16	64	16	48	40	8
9	08880-83351	TMO SYN 15-40 DIESEL 1LT	32	17	40	32	20	12
10	08880-83352	TMO SYN 15-40 DIESEL 4LT	8	4	16	5	8	3
11	08880-83575	TMO SYN 10-40 GASOLINE 1LT	1	5	1	4	3	1
12	08880-83576	TMO SYN 10-40 GASOLINE 4LT	4	3	3	9	5	4
13	08885-80929	TMO TRANS OIL	4	5	5	8	5	3
14	08885-80930	TMO DIFF OIL	4	6	4	3	2	1
15	12157-10010	GASKET DIFF	6	4	12	9	6	3
16	15601-BZ030	OF AVANZA/AGYA	8	8	4	4	8	4
17	15601-YZZT1	OF AVANZA RUSH	8	16	20	16	20	4
18	23390-0L070-82	FUEL FILTER GD EG	24	8	12	16	10	6
19	23390-YZZA1-82	FUEL FILTER KD EG	8	8	8	12	8	4
20	31210-BZ021	COVER CLUTH	3	3	4	4	8	4
21	31250-BZ130	DISC CLUTH	3	5	3	8	6	2
22	5210	BATTERY LIQUID	1	1	4	8	5	3
23	85212-BZ210	WIPPER BLADE RH	1	1	4	8	5	3
24	85222-BZ220	WIPER BLADE LH	3	6	3	5	7	2
25	9004A-91032	SPARK PLUG AVANZA NON VVTI	5	3	4	3	5	2
26	9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	4	2	3	2	5	3
27	90430-GASKET	GASKET ENGINE	6	6	8	8	5	3
28	90430-GEAR-A	GASKET TRANS SMALL	2	2	2	3	2	1
29	90430-GEAR-B	GASKET TRANS BIG	11	7	6	11	6	5
30	90915-YZZD2-82	OF INNOVA, FORTUNER	3	2	2	4	8	4

(2) Analysis of MAD in Forecasting using the SMA Method.

At this stage, one part number is selected from 30 datasets, and the chosen part number is 9004a-91065. The data used is shown in Table 10 below:

Table 10 Sample Forecasting with SMA Method

PART NUMBER	PART NAME	PERIOD T				FT
		SEPT	OKT	NOV	DEC	
9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6	6,000

$$MAD = \frac{\sum|At-Ft|}{n} \quad (11)$$

$$At(DEC) = 6 \quad (12)$$

$$Ft(DEC) = 6 \quad (13)$$

$$MAD = \frac{\sum|6-6|}{1} = 0 \quad (14)$$

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Based on the above calculation, the MAD calculation result for part number 9004A-91065 is 0.000, which when implemented in the Table 11 appears as follows:

Table 11 Implementation on the SMA Forecasting Dataset sample

PART NUMBER	PART NAME	PERIOD T				FT	MAD
		SEPT	OKT	NOV	DEC		
9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6	6,000	0,000

When implemented on the following 30 data of SMA forecasting method, the results of the MAD calculation can be seen in the table 12 below.

Table 12 MAD Validation Implementation on SMA Forecasting Dataset

NO	PART NUMBER	PART NAME	PERIOD T				FT	MAD
			SEPT	OKT	NOV	DEC		
1	01088-BRAKE	BRAKE CLEANER	30	35	36	42	33,667	8,333
2	01088-CABIN	CABIN CLEANER	18	18	23	30	19,667	10,333
3	01088-FLUSH	ENGINE FLUSH	26	14	21	26	20,333	5,667
4	01088-INJCT	INJECTOR CLEANER FOAM	7	11	5	8	7,667	0,333
5	01088-INCTDIS	INJECTOR DIESEL	8	7	6	13	7,000	6,000
6	02088-INJCT	INJECTOR LIQUID	16	9	14	14	13,000	1,000
7	04465-BZ170	BRAKEPAD AVANZA	8	9	8	11	8,333	2,667
8	08808-80060	WIPPER FLUID	7	11	15	29	11,000	18,000
9	08880-83351	TMO SYN 15-40 DIESEL 1LT	12	23	12	23	15,667	7,333
10	08880-83352	TMO SYN 15-40 DIESEL 4LT	16	18	16	25	16,667	8,333
11	08880-83575	TMO SYN 10-40 GASOLINE 1LT	26	19	21	33	22,000	11,000
12	08880-83576	TMO SYN 10-40 GASOLINE 4LT	46	39	43	52	42,667	9,333
13	08885-80929	TMO TRANS OIL	14	17	23	20	18,000	2,000
14	08885-80930	TMO DIFF OIL	20	24	31	33	25,000	8,000
15	12157-10010	GASKET DIFF	22	24	28	32	24,667	7,333
16	15601-BZ030	OF AVANZA/AGYA	28	15	17	28	20,000	8,000
17	15601-YZZT1	OF AVANZA RUSH	9	15	12	14	12,000	2,000
18	23390-0L070-82	FUEL FILTER GD EG	5	2	1	4	2,667	1,333
19	23390-YZZA1-82	FUEL FILTER KD EG	2	6	3	5	3,667	1,333
20	31210-BZ021	COVER CLUTH	2	1	4	3	2,333	0,667
21	31250-BZ130	DISC CLUTH	2	1	4	3	2,333	0,667
22	5210	BATTERY LIQUID	21	20	25	31	22,000	9,000
23	85212-BZ210	WIPPER BLADE RH	3	4	6	11	4,333	6,667
24	85222-BZ220	WIPER BLADE LH	3	4	6	11	4,333	6,667
25	9004A-91032	SPARK PLUG AVANZA NON VVTI	20	32	8	28	20,000	8,000
26	9004A-91065	SPARK PLUG AVANZA AGYA	9	6	3	6	6,000	0,000
27	90430-GASKET	GASKET ENGINE	59	53	53	79	55,000	24,000
28	90430-GEAR-A	GASKET TRANS SMALL	8	10	18	16	12,000	4,000
29	90430-GEAR-B	GASKET TRANS BIG	10	6	8	6	8,000	2,000
30	90915-YZZD2-82	OF INNOVA, FORTUNER	17	17	17	26	17,000	9,000

- Analysis of MAPE Calculation.

(1) Analysis of SMA Error MAPE calculation on conventional forecasting method.

Following is Table 13 containing the data used in the calculation of MAPE, namely the data with part code 08880-83576, which can be seen below:

Table 13 Sample Forecasting with Conventional Methods

PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD
		SEPT	OKT	NOV	DEC		
08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67	80	13

PE calculation:

$$PEt = (\frac{80-67}{80}) \quad (15)$$

$$PEt = \frac{13}{80}) \quad (16)$$

$$PEt = 0.16 \quad (17)$$

MAPE calculation:

$$\sum_{t=1}^{n} = 1\frac{0.16}{1}x100\%... \quad (18)$$

$$\sum_{t=1}^{n} = 16\%... \quad (19)$$

Based on the MAPE calculation, the forecasting result for part number 08880-83576 using the conventional method is 16%, The result of the MAPE calculation can be seen in the following Table 14:

Table 14 MAPE Forecasting Validation on Conventional Forecasting Methods

PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD	MAPE
		SEPT	OKT	NOV	DEC			
08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67	80	13	16%

The following is the result and application of the MAPE calculation on conventional method forecasting for 30 datasets, the result of the calculation and application can be seen in the following table 15 in below.

Table 15 Implementation of MAPE Validation on Conventional Dataset Forecasting methods

NO	PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD	MAPE
			SEPT	OKT	NOV	DEC			
1	08880-83576	TMO SYN 10-40 GASOLINE 4LT	64	72	48	67	80	13	16%
2	08880-83575	TMO SYN 10-40 GASOLINE 1LT	48	42	72	64	48	16	33%
3	08880-83352	TMO SYN 15-40 DIESEL 4LT	36	24	32	48	28	20	71%
4	08880-83351	TMO SYN 15-40 DIESEL 1LT	48	27	72	48	36	12	33%
5	08885-80929	TMO TRANS OIL	24	12	32	32	24	8	33%
6	08885-80930	TMO DIFF OIL	27	12	36	48	28	20	71%
7	15601-BZ030	OF AGYA/CALYA/GRAND AVANZA	32	32	64	32	40	8	20%
8	15601-YZZT1	OF AVANZA LAMA / RUSH	16	64	16	48	40	8	20%
9	90915-YZZD2-82	OF INNOVA / FORTUNER	32	17	40	32	20	12	60%
10	90915-YZZE1-82	OF YARIS / ALTIS	8	4	16	5	8	3	38%
11	17801-BZ100	AIR FILTER AGYA	1	5	1	4	3	1	33%
12	17801-BZ050	AIR FILTER AVANZA	4	3	3	9	5	4	80%
13	17801-BZ150	AIR FILTER GRAND NEW AVANZA	4	5	5	8	5	3	60%
14	17801-YZZA1	AIR FILTER INNOVA, FORTUNER	4	6	4	3	2	1	50%
15	9004A-91065	SPARK PLUG AGYA	6	4	12	9	6	3	50%
16	9004A-91016	SPARK PLUG AVANZA NON VVTI	8	8	4	4	8	4	50%
17	9004A-91032	SPARK PLUG AVANZA VVTI, RUSH	8	16	20	16	20	4	20%
18	90919-T1004	SPARK PLUG INNOVA, FORTUNER, HILUX	24	8	12	16	10	6	60%
19	90919-T1002	SPARK PLUG YARIS	8	8	8	12	8	4	50%
20	88568-BZ040	FILTER AC AVANZA F601, F651	3	3	4	4	8	4	50%
21	88568-BZ050	FILTER AC AGYA, GRANDNEW AVZ	3	5	3	8	6	2	33%
22	85212-BZ210	WIPPER BLADE RH	1	1	4	8	5	3	60%
23	85222-BZ220	WIPER BLADE LH	1	1	4	8	5	3	60%
24	90049-51125	BULB HEADLAMP ORI	3	6	3	5	7	2	29%
25	90049-51185	BULB H-16 (FOGLAMP AVZ) ORI	5	3	4	3	5	2	40%
26	99132-21230-76	BULB REM	4	2	3	2	5	3	60%
27	23390-YZZA1-82	FUEL FILTER GD EG	6	6	8	8	5	3	60%
28	23390-0L070-82	FUEL FILTER KD EG	2	2	2	3	2	1	50%
29	04465-BZ170	BRAKE PAD AVANZA	11	7	6	11	6	5	83%
30	04465-0K430	BRAKE PAD INNOVA REBORN	3	2	2	4	8	4	50%

Based on the implementation of MAPE on the conventional forecasting method dataset, the smallest error obtained is 16%, and the largest error is 83%.

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(2) Analysis of MAPE (MAPE) calculation in forecasting using the SMA method.

Following is Table 16 containing the data used in thecalculation of MAPE, namely the data with part code 9004A-91065, which can be seen follows:

Table 16 Sample Forecasting with SMA Method

PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD
		SEPT	OKT	NOV	DEC		
9004A-91065	SPARK PLUG AVANZA AGYA	9	6	3	6	6	0

PE calculation:

$$PEt = (\frac{6-6}{6}) \quad (20)$$

$$PEt = \frac{0}{6} \quad (21)$$

$$PEt = 0 \quad (22)$$

MAPE calculation:

$$\sum_{t=1}^{n} = 1\frac{0}{1}x100\% \ldots \quad (23)$$

$$\sum_{t=1}^{n} = 0\% \ldots \quad (24)$$

Based on the calculation of MAPE, the forecasting result of the SMA method for part number 900A-91065 is 0%, which when implemented in the Table 17 appears as follows:

Table 17 MAPE Forecasting Validation on SMA Forecasting Method

PART NUMBER	PART NAME	PERIOD T				FT (DEC)	MAD	MAPE
		SEPT	OKT	NOV	DEC			
9004A-91065	SPARK PLUG AVANZA AGYA	9	6	3	6	6	0	0,000%

Based on the implementation of MAPE on the SMA forecasting dataset, the smallest error obtained was 0.000% and the largest error was 62.069%.

- Implementation of Inventory System with Forecasting implementation

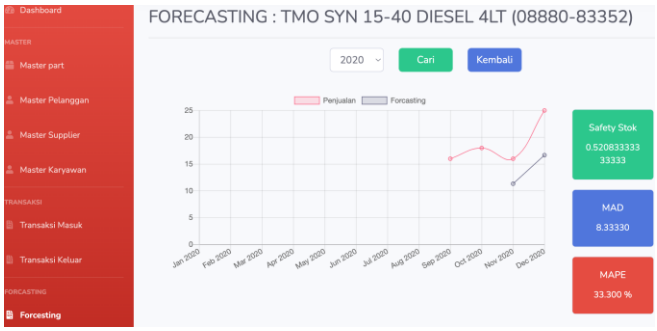

Figure 2 Inventory System with Forecasting Implementation

Based the result and application of the MAPE calculation on SMA method forecasting for 30 datasets, the result of the calculation and application can be seen in the following Table 18 below.

Table 18 Implementation of MAPE Analysis on the SMA Dataset Forecasting method

NO	PART NUMBER	PART NAME	PERIOD T				FT	MAD	MAPE
			SEPT	OKT	NOV	DEC			
1	01088-BRAKE	BRAKE CLEANER	30	35	36	42	33,667	8,333	19,841 %
2	01088-CABIN	CABIN CLEANER	18	18	23	30	19,667	10,333	34,444 %
3	01088-FLUSH	ENGINE FLUSH	26	14	21	26	20,333	5,667	21,795 %
4	01088-INJCT	INJECTOR CLEANER FOAM	7	11	5	8	7,667	0,333	4,167%
5	01088-INCTDIS	INJECTOR DIESEL	8	7	6	13	7,000	6,000	46,154 %
6	02088-INJCT	INJECTOR LIQUID	16	9	14	14	13,000	1,000	7,143%
7	04465-BZ170	BRAKEPAD AVANZA	8	9	8	11	8,333	2,667	24,242 %
8	08808-80060	WIPPER FLUID	7	11	15	29	11,000	18,000	62,069 %
9	08880-83351	TMO SYN 15-40 DIESEL 1LT	12	23	12	23	15,667	7,333	31,884 %
10	08880-83352	TMO SYN 15-40 DIESEL 4LT	16	18	16	25	16,667	8,333	33,333 %
11	08880-83575	TMO SYN 10-40 GASOLINE 1LT	26	19	21	33	22,000	11,000	33,333 %
12	08880-83576	TMO SYN 10-40 GASOLINE 4LT	46	39	43	52	42,667	9,333	17,949 %
13	08885-80929	TMO TRANS OIL	14	17	23	20	18,000	2,000	10,000 %
14	08885-80930	TMO DIFF OIL	20	24	31	33	25,000	8,000	24,242 %
15	12157-10010	GASKET DIFF	22	24	28	32	24,667	7,333	22,917 %
16	15601-BZ030	OF AVANZA/AGYA	28	15	17	28	20,000	8,000	28,571 %
17	15601-YZZT1	OF AVANZA RUSH	9	15	12	14	12,000	2,000	14,286 %
18	23390-0L070-82	FUEL FILTER GD EG	5	2	1	4	2,667	1,333	33,333 %
19	23390-YZZA1-82	FUEL FILTER KD EG	2	6	3	5	3,667	1,333	26,667 %
20	31210-BZ021	COVER CLUTH	2	1	4	3	2,333	0,667	22,222 %
21	31250-BZ130	DISC CLUTH	2	1	4	3	2,333	0,667	22,222 %
22	5210	BATTERY LIQUID	21	20	25	31	22,000	9,000	29,032 %
23	85212-BZ210	WIPPER BLADE RH	3	4	6	11	4,333	6,667	60,606 %
24	85222-BZ220	WIPER BLADE LH	3	4	6	11	4,333	6,667	60,606 %
25	9004A-91032	SPARK PLUG AVANZA NON VVTI	20	32	8	28	20,000	8,000	28,571 %
26	9004A-91065	SPARK PLUG AVANZA VVTI, RUSH	9	6	3	6	6,000	0,000	0,000%
27	90430-GASKET	GASKET ENGINE	59	53	53	79	55,000	24,000	30,380 %
28	90430-GEAR-A	GASKET TRANS SMALL	8	10	18	16	12,000	4,000	25,000 %
29	90430-GEAR-B	GASKET TRANS BIG	10	6	8	6	8,000	2,000	33,333 %
30	90915-YZZD2-82	OF INNOVA, FORTUNER	17	17	17	26	17,000	9,000	34,615 %

The image shown in Figure 2 is the display on the forecasting page, which consists of two main graphs: the actual sales graph represented in red, showing the sales of spare parts for one month, and the forecasting graph represented in grey, showing the predicted spare parts sales for one month. The forecasting page also displays the analysis results of forecasting error using MAD and MAPE

CONCLUSION AND RECOMMENDATION

The smallest error value obtained from the SMA forecasting method was 0.000%, while the largest was 62.069%. In contrast, the conventional method had the smallest error value of 14% and the largest of 83.333%. Therefore, it can be concluded that the SMA method is more optimal than the conventional forecasting method.

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