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Spare Parts Demand Forecasting During Covid 19 pandemic (Automotive Company Case Study)

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Abstract: The research was conducted to analyze the calculation of demand forecasting and inventory of spare parts . The data collection method uses descriptive quantitative by conducting literature studies, interviews, and collecting sample data of 140 spare parts from June 2019 to June 2020. The data classification process with FSN method, obtained 13 fast moving spare parts use for calculating demand forecasting based on the Triple Exponential Smoothing method. The results from the trial error to get the smoothing value of alpha, beta and gamma errors prioritize to best MAPE <5%. Some MAPE errors above 5% are X000000 000254 MAPE = 5.68%, X000000 005566 MAPE = 21.12, X400 401 10 72 MAPE = 13.14, and X400 401 26 71 MAPE = 16.70. The calculation result of safety stock and reorder point find 4 spare parts have low level inventory have to reorder.

Keywords: Forecasting, Triple Exponential Smoothing, Safety Stock, Reorder Point

INTRODUCTION

Spare parts are very important for company operational in the automotive industry. Considering the availability of spare parts is very important in supporting after-sales service to consumers. The consumer satisfaction with the availability of vehicle parts very high influences to the company's progress and consumer confidence in the vehicle products they buy. The availability of spare parts are influenced by several things such as demand, damage uncertainty factors, and some of parts that are difficult to find by.

This research was conducted at PT. XYZI as main distributor company of commercial vehicle brand holders for buses, trucks and spare parts. In the aftersales and logistic process the sales process are not directly supply from PT XYZI to the end customer. Through dealer intermediaries as retailers, all requests and sales to end customers are met. And to meet the needs of vehicles and spare parts the dealer will send the orders to PT. XYZI.

Refer to data research of demand and inventory find some change in demands level and stock inventory availability. In March 2020 - June 2020 demand decreased due to PSBB condition because Covid-19 pandemic. According to Sugiyono Madelan (2020) during the pandemic if a distribution center is infected, quarantine measures are carried out for 14 days or more. The existence of this PSBB policy has impact on decreasing demand and spare parts supply.

The research purpose to analyst spare parts demand and inventory due to dealer and customer requirement during pandemic using demand forecasting and inventory control . High accuracy demand forecasting can be used as a reference in planning, controlling and decision making. And the inventory level control can help to monitor the stock availability to fulfil the demands.

Research Problem Formulation

Based on problems identification above can be formulated:

1. How to identify parts based on their movement classification and find the demand forecast next period for fast moving spare parts criteria.
2. How to know the condition of the spare parts inventory level based

Research Objectives

1. To determine the demand forecast by Tripel Eksponential Smoothing for next period on Juli 2020 on fast moving parts.
2. To determine the inventory stock level by safety stock dan reorder point for Juli 2020.

LITERATURE REVIEW

Inventory Management

Inventory management aims to make inventory storage carried out efficiently, reduce inventory costs and minimize the time used to control inventory. According to Ahmad Badawi Saluy and Sugiyono Madelan (2021) the damage of goods due to storage causes expenses which should not be incurred. The others purposes are to optimize the use of inventory in order to gain profit and increase customer satisfaction (Heizer and Render, 2017).

Demand

Demand is the amount of goods or services that consumers or individuals require to buy in certain time. According to Heizer and Render (2017) there are two types of requests, namely:

1. Independent Demand (Independent Demand). The demand for goods that does not depend on the demand for other goods.
2. Dependent Demand (Dependent Demand). The demand for goods that depend on the demand for other goods because they are related.

Demand has an important role in supply chain management. The amount of supply and demand for spare parts will be very easy to adjust if the amount of demand remains constant over time. However, if the amount of demand is not fixed then the level of supply must be adjusted.

FSN Method

FSN Is a method to grouping based on the pattern of use of goods. The movement of goods is grouped into Fast moving (F), Slow moving (S) and Non-moving (N) (Brindha 2014). In terms of the level of movement of spare parts demand, FSN can assist in identifying spare parts with high turnover which are beneficial items that need to be reviewed regularly. FSN can also be used to identify spare parts whose movement is seasonal and spare parts are not active (dead stock). FSN classification process in three steps (Nadkarni dan Ghewari 2016):

1. *Average stay (AS)*, is the average item that stay on inventory. Based on the cumulative comparison of 10% in group F, cumulative average stay amounted to 20% in group S, and cumulative 70% in group N. The equation to use as follows:

   AS = *Cumulative inventory holding balance* / (*Opening balance* + *Total receive quantity*)

2. *Consumption rate* (CR) is the level of consumption of goods. Based on the cumulative comparison amounted to 70% in group F, cumulative consumption rate amounted to 20% in group S, and 10% in group N. The equation to use as follows:

   CR = *Total issue quantity* / *Total period duration*

3. The final classification to combine the results of average stay and consumption rate by plot according to matrix table final classification of FSN.

Forecasting

Forecasting is the analysis process that aims to estimate the future situation by using certain methods with variables that have an effect in it based on the exploration of past data. Although the forecasting results are not entirely perfect, they can be used as a direction for future.

Some principles of forecasting must be considered to get good forecasting results (Sofyan, 2013):

1. Forecasting has deviations and only can reduce uncertainty but not eliminate uncertainty.
2. It is important in forecasting to inform the magnitude of deviations contained in the calculations performed.
3. The longer the forecast period, the less accurate it will be. Because in short-term forecasting the factors that influence are less than long-term forecasting.
4. Forecasting on aggregate (grouping items) is more accurate than forecasting on disaggregated. In disaggregated forecasting, the standard deviation (difference deviation) relative to the mean becomes larger.

Forecasting method of Triple Exponential Smoothing is based on three smoothing equations for level, trend, and seasonal with the smoothing constant level value of $0 \leq \alpha \leq 1$, trend $0 \leq \beta \leq 1$ and seasonal $0 \leq \gamma \leq 1$. The exponential smoothing method requires initial values using the initialization process from the past data. If past data do not exist, the alternative is wait until data available, or use any value that makes sense. The following is the formulation uses:

$$\textbf{\textit{Level}}: \boldsymbol{L_t = \alpha \frac{y_t}{S_{t-s}} + (1-\alpha)(L_t + b_{t-1})}$$

$$\textbf{\textit{Tren}}: \boldsymbol{b_t = \beta(L_t - L_{t-1}) + (1-\beta) b_{t-1}}$$

***Seasonal* :** $S_t = \gamma \frac{y_t}{L_t} + (1-\gamma) S_{t-s}$

***Forecasting* :** $F_{t+m} = (L_t + b_t m) S_{t-s+m}$

In forecasting the error measurements need to measure the deviation of the forecasting result accuration . There are three measurement errors to monitor forecasts and to compare different forecasting models (Heizer dan Render 2017):

a. Mean Absolute Percent Error (MAPE)

To measure the error based on the absolute mean deviation between the predicted value and the actual value and expressed as percentage. The MAPE formulated as follows:

$$\mathbf{MAPE} = \frac{\sum_{i=1}^{n} 100[\mathbf{Aktual}_i - \mathbf{Peramalan}_i)/\mathbf{Aktual}_i}{\mathbf{n}}$$

MAPE is the most used for measurement of forecasting accuracy. MAPE has important desirable features such as reliability, ease of interpretation, clarity of presentation, support for statistical evaluation, and the use of all information about the error (Moreno 2013).

Table 1.Interpretation of MAPE

Percentage Nilai *Range* MAPE	
MAPE	**Interpretasi**
< 10 %	Peramalan sangat akurat
10 % - 20 %	Peramalan Baik
20 % - 50 %	Peramalan masih dapat diterima
> 50 %	Peramalan tidak akurat lagi

Another indication for the best MAPE is < 5% , means the forecast is very accurate and correct (Swanson, 2015).

b. Mean Absolute Deviation (MAD)

MAD use to measure the error by comparing the actual data with the predicted data then taking the absolute value of the error and dividing it by the number of periods. The formula using in MAD is:

$$\mathbf{MAD} = \frac{\Sigma[\mathbf{Aktual} - \mathbf{Peramalan})}{\mathbf{n}}$$

c. Mean Square Error (MSE)

MSE measuring the error by using the value of the actual difference with the forecast squared. The MSE is using formula as follows:

$$\mathbf{MSE} = \frac{\Sigma[\mathbf{Aktual} - \mathbf{Peramalan})^2}{\mathbf{n}}$$

Safety Stock

In a condition of uncertainty in the demand for spare parts, safety supplies are needed to overcome the lack of inventory when there is demand during lead time. In condition demand and waiting time are constants, it does not need safety stock (Pujawan 2021). The equation used in the calculation of safety stock is:

$$\textbf{Safety Stock (SS)} = \mathbf{Z \times Sdl}$$
$$\mathbf{Sdl = Sd \times \sqrt{l}}$$

Reorder Point

The Reorder point indicate the value of the inventory level must reorder when reaches the level point. Reorder point (ROP) is the number of orders calculated from the multiplication between the time of the order and daily demand added by the safety stock (Heizer dan Render, 2017). Following the formula to calculate Reorder point:

$$\textbf{Daily demand (d)} = \mathbf{D/n}$$

$$\mathbf{ROP = (d \times LT) + SS}$$

RESEARCH_METHODS

Research Design

In this research uses descriptive quantitative method, with sample data measure in statistical analysis to explain the relationship between:

1. Number of inventory, number of outgoing parts, and number of receiving parts to research parts classification based on the movement.
2. The actual number of demands as the basis of classifying spare parts to research future demand forecasting with high accuracy.
3. Amount of safety stock and reorder level used as regulation of spare parts inventory level

Data Sources

The research data is primary data from PT XYZI. The population is using the actual demand data for all spare parts with samples taken using the actual demand data for 140 spare parts from July 2019 to June 2020. The data collection techniques were carried out through library research from literature studies, international and national journals in previous studies as well. Field research by conducting direct observations of the research object, company documents, and unstructured interviews with aftersales and inventory staff and managers

Analysis Methods

Data analysis was carried out after the data sources were collected and and using FSN classification methods, Triple Exponential Smoothing forecasting method with software Minitab 19, Safety Stock and Reorder Point methods with software POM QM for windows.

FINDINGS AND DISCUSSION

FSN Classification

A. Average Stay FSN

The following is the calculation of the average stay for spare parts code X000 090 15 51, with the known cumulative no of inventory holding value of 8133, opening balance of 2238, and total quantity received of 4505.

$$\text{Average stay} = \frac{\text{Cumulative no.of Inventory holding}}{(\text{Opening balance} + \text{Total receive quantity})} = \frac{8133}{2238 + 4505} = 1{,}21$$

The average stay value define how much the average value of spare parts remains. More higher the average stay value, the more longer the spare parts are stored in inventory.

Table 2. Average Stay classification on spare parts

No.	Kode Suku Cadang (Spare Part)	Average Stay	Cum. Average Stay	Persentase (%) = Cumulative AS/ Total AS	F/S/N Average Stay
1	X000000 001072	9,78	9,78	2%	N
2	X400 323 04 00	9,50	19,27	4,4060%	N
...					
67	X400 353 97 62	2,95	315,93	72,2313%	S
68	X000 322 32 85	2,84	318,77	72,8796%	S
...					
117	X541 180 02 09	1,29	416,39	95,1994%	F
118	X000 090 15 51	1,21	417,60	95,4751%	F
...					
140	X000 989 84 02	0,34	437,35	100,0000%	F
	Total :	437,39			

The results of the calculation of the average stay value are sorted from largest to smallest. With grouped by 70% of the cumulative value as N found 63 items, 20% of the cumulative value as S category of 39 items, and 10% of the cumulative value as F category of 38 items.

B. Consumption Rate FSN

The following is the calculation of the consumption rate for the spare part code X000 090 15 51 as known the total issue is 5392 and the total period duration is 12 months.

Consumption rate $= \frac{\text{Total issue quantity}}{\text{Total period duration}} = \frac{5392}{12} = 449{,}33$

The consumption rate define more higher the value, more higher rate of the spare parts movement.

Table 3. Consumption Rate classification on spare parts

No.	Kode Suku Cadang (Spare Part)	Consumption Rate	Cum. Consumption Rate	Persentase (%) = Cumulative CR/ Total CR	F/S/N Consumption Rate
1	X906 180 02 09	1114,75	1114,75	14,9004%	F
2	X400 092 00 05	573,67	1688,42	22,5684%	F
3	X000 090 15 51	449,33	2137,75	28,5745%	F
...					
20	X400 477 00 02	101,67	5314,92	71,0424%	S
21	X541 997 03 45	101,17	5416,08	72,3946%	S
...					
138	X009 096 92 99	1,67	7478,58	99,9632%	N
139	X400 460 15 00	1,50	7480,08	99,9833%	N
140	X947 260 07 57	1,25	7481,33	100%	N

The results of the calculation consumption rate are sorted from the largest to the smallest. Grouped by 70% of the cumulative value as F category was found 19 items, 20% of the cumulative value as S category of 27 items, and 10% of the cumulative value as N of 94 items.

C. Final FSN

Combining classification result of the average stay with the consumption rate based on the final FSN grouping matrix. The final FSN classification results from 140 spare parts data are 13 items classified as fast moving, 39 items slow moving and 88 items non-moving.

Triple Exponential Smoothing Forecasting

Using 13 high-moving parts as fast moving items to conduct analysis based on the plot of demand data history for the 12-month period from July 2019 to June 2020 to obtain the forecasting value of the next period. The triple exponential smoothing method is used to get the smallest error value MAPE, MAD and MSD (MSE) from trial error input α, γ, and δ on each item.

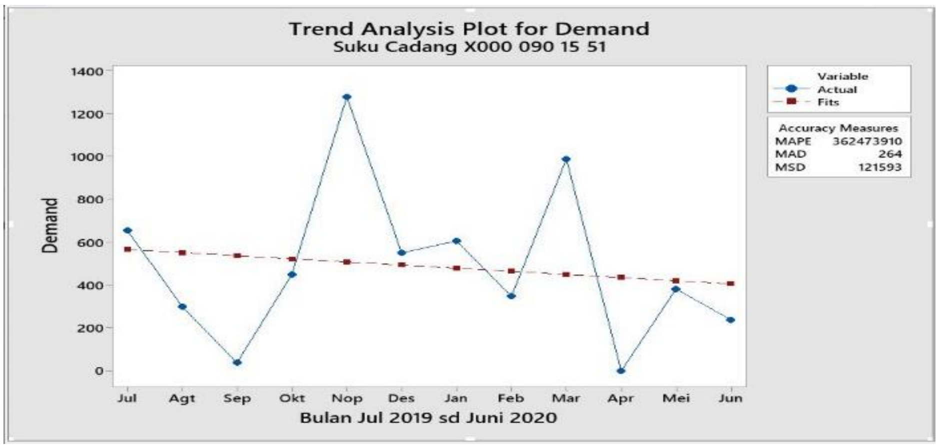

Figure 1. Trend data mapping for spare part X000 090 15 51

On figure 1 above is demand data mapping for spare part X000 090 15 51 with decline trendline pattern, on the Fits redline is the estimate trend demand. With this trend analysis generate high error on MAPE, Mad and MSD.

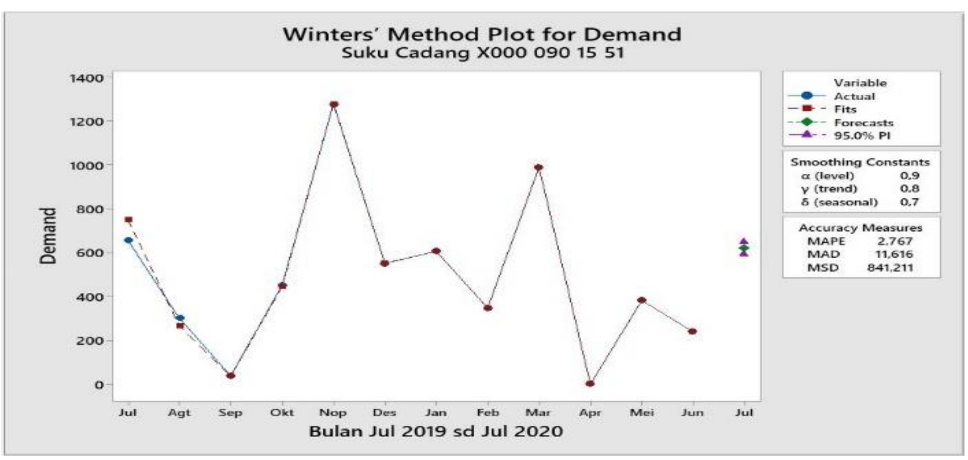

Figure 2. Triple Exponential Smoothing forecasting result for X000 090 15 51

So then the mapping carried out using Triple Exponential Smoothing (Winter's Method). The red line of Fits which depicts the estimated seasonal value is almost the same as the blue line that describes the actual demand value and with a smaller error value. The result of trial error find the smallest error with smoothing level α = 0.9; trend γ = 0.8 and seasonal δ = 0.7 resulting in MAPE = 2.767; MAD = 11,616 and MSD = 841,211.

Table 4 Optimum Soothing result on Level (α), Trend (γ), and seasonal (δ)

No	Kode Suku Cadang	α (level)	γ (trend)	δ (seasonal)	MAPE	MAD	MSD	Peramalan Berikutnya 13
1	X000 090 15 51	0,9	0,8	0,7	2,77	11,62	841,21	622
2	X000 180 29 09	0,9	0,8	0,7	1,25	1,38	11,62	181
3	X000 477 01 03	0,9	0,8	0,7	4,47	5,62	172,44	164
4	X000000 000254	0,9	0,8	0,7	5,68	4,90	119,04	122
5	X000000 005566	0,9	0,7	0,5	21,12	5,95	147,35	38
6	X400 092 00 05	0,9	0,7	0,5	1,60	8,07	263,33	325
7	X400 401 10 72	0,9	0,7	0,5	13,14	7,93	391,94	113
8	X400 401 26 71	0,9	0,7	0,5	16,70	4,49	135,97	57
9	X400 421 10 30	0,9	0,7	0,5	2,13	4,46	91,90	96
10	X400 421 18 30	0,9	0,9	0,9	3,21	7,77	283,18	232
11	X541 090 01 51	0,9	0,9	0,9	2,24	4,89	142,66	349
12	X541 180 02 09	0,9	0,8	0,7	3,25	4,14	98,76	176
13	X906 180 02 09	0,9	0,7	0,5	4,81	65,08	25345,85	1913

The search for the smallest MAPE value is prioritized followed by MAD and MSE. MAPE is prioritized because the size of the forecasting variable is an important factor in evaluating forecasting accuracy. From the trial and error results obtained MAPE <5% error on 9 items, MAPE <10% on 1 item; 10% <MAPE <20% on 2 items and 20% <MAPE <50% on 1 item.

Safety Stock and Reorder Point

Using daily demand historical and has defined for the *Working days (n)* 25 days, *Lead time (l)* for 21 days dan *Service Level (Z)* 95% . Followings are the *safety stock and reorder point* calculations foe next period on July 2020 for spare part X000 090 15 51.

Table 5. Daily demand for Safety Stock and Reorder Point spare part X000 090 15 51

Tanggal	*Demand*	*(Demand - Mean)*	*(Demand-Mean)^2*
02/06/2020	5	-4,52	20,43
09/06/2020	8	-1,52	2,31
13/06/2020	200	190,48	36282,63
23/06/2020	25	15,48	239,63
Total	238		36545

Calculated:
Mean = 238 / 25 days= 9,25
((*Demand-Mean*)^2)/(n-1) = 36545/(25-1) = 1522,71
Standar deviasi (Sd) = $\sqrt{1522{,}71}$ = 39,02
With above information put to POM QM to have the calculation of safety stock and reorder point:

SS dan ROP Suku cadang X000 090 15 51 Solution				
Value			Parameter	Value
(Daily) Demand (d-bar)	9,25		Z value	1,64
(Daily) Demand std dev (sigma-d)	39,02		Expected demand during le...	194,25
Service level %	95		Safety Stock	293,25
Lead time (in days) (L)	21		Reorder point	487,5
Lead time std dev (sigma L)	0			

Figure 3. POM QM calculation result safety stock & ROP spare part X000 090 15 51

The final results of the safety stock and reorder points calculation for the 13 spare parts defined that reorder must be carried out on spare parts X400 401 10 72, X400 401 26 71, X400 421 18 30 and X541 090 01 51. Due to the volume at the end of June 2020 (closing balance) is less than the safety stock value, then reorder must be made until the inventory quantity reaches reorder point level.

Table 6. Calculation results Safety Stock and Reorder Point

No	Kode Suku Cadang	*Demand* Juni 2020	*Closing Balance* Juni 2020	*Safety Stock*	*Reorder Point*
1	X000 090 15 51	238	1351	294	488
2	X000 180 29 09	166	828	220	360
3	X000 477 01 03	88	376	60	134
4	X000000 000254	220	365	152	337
5	X000000 005566	80	634	81	148
6	X400 092 00 05	375	1612	171	486
7	X400 401 10 72	697	0	308	893
8	X400 401 26 71	394	226	241	572
9	X400 421 10 30	65	511	88	143
10	X400 421 18 30	285	128	366	605
11	X541 090 01 51	566	268	291	767
12	X541 180 02 09	67	161	67	123
13	X906 180 02 09	1263	2343	793	1854

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the results and analysis that has been carried out above, the following conclusions can be determined:

1. In identifying the movement level of spare parts by grouping them and reducing the deviation level in the forecasting process as well as. From the results of the classification, using the FSN method has selected 13 fast moving spare parts obtained with fluctuating demand. The results of the trend line pattern show differences with the forecasting results, and the error generated is very high. The increase in demand caused by these promotional programs forms a seasonal pattern. By using seasonal smoothing in triple exponential smoothing produces smaller error value.
2. The result of the calculation of Safety stock and Reorder pont for the next period in July 2020 obtained 4 spare parts with inventory conditions below the safety stock value limit and reorder point. This is due to the delay in delivery during the PSBB period. While other parts have more inventory remaining than safety stock and reorder point level that can fulfil the

inventory for July 2020..

Recommendations

The marketing strategy carried out by many promotional programs throughout the year can help to increase the demand. The strategy can cause the Bullwhip effect because buyers prefer to stock up when prices fall. The use of forecasting can help provide information on forecasting future demand. Forecasting can use as a strategy in determining the target demand in the sale of spare parts. By prioritizing the best MAPE value <5%, there are MAPE errors above 5% on spare parts X000000 000254 MAPE = 5.68 % , X000000 005566 MAPE = 21.12, X400 401 10 72 MAPE = 13.14, and X400 401 26 71 MAPE = 16.70. In further research, recommend to use others forecasting methods to get smaller error values and more accurate forecasting result.

To improve the after-sales service level, spare parts should have a safety stock in storage. If high demand or unexpected requests come can be immediately fulfilled. Safety stock and reorder points can use to maintain the amount of inventory in storage. From the research results, some spare parts need attention. The parts have less inventory stock on X400 401 10 72, X400 401 26 71, X400 421 18 30 and X541 090 01 51 have to reorder. The others spare parts have very high inventory cause the over stock. For further research recommend to use the Optimum Order Quantity (EOQ) method which can help to determine the optimal level value in inventory.

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