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Optimizing Spare Parts Inventory Management of Truck Dealer Services using Forecasting Methods and Continuous Review System Approach

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***Abstract*—A truck dealership company, specializing in maintenance, repair, and spare parts sales, faces stockout challenges that hinder its ability to meet demand for moving code 1 spare parts. The absence of effective forecasting methods and safety stock policies exacerbates these issues. This study aims to optimize inventory management by identifying suitable forecasting methods and implementing the Continuous Review System (CRS) to establish safety stock and reorder points as the parameter for procurement planning. The results indicate that the Double Exponential Smoothing (DES) method effectively predicts demand, while the Monte Carlo simulation method performs better for spare part 493051110L. The CRS approach improves the fill rate and reduces stockout risks, ensuring better inventory management for the company. These findings provide a framework for the company to enhance its spare parts inventory strategy, contributing to improved service reliability and operational efficiency.**

***Keywords*— Spare Parts, Inventory Management, Stockout, Fill Rate.**

I. INTRODUCTION

The growth of the automotive industry sector in Indonesia shows positive developments, especially seen from the export value of four-wheeled vehicles reaching USD 6,128.2 million in 2022, an increase of 29.20% compared to 2020 [1]. Projections show that this figure will continue to increase. Data also shows that the number of motorized vehicles, especially trucks, continues to increase from 2018 to 2022, reflecting the high demand for automotive products. This high demand creates tight competition among automotive companies, where service levels are key to achieving competitive advantage [2][3]. There are two types of service levels: type I which considers each order and type II (fill rate) which measures the proportion of demand that can be met [4].

The company analyzed in this study plays a significant role in the automotive industry but struggles to meet spare parts demand, with a fill rate of only 30% to 40% in 2023. This indicates that PT XYZ has been unable to fulfill more than half of the incoming spare part requests, frequently experiencing stockouts during periods of increased demand.

To address this issue, optimizing inventory management is critical to prevent both stockouts and overstocks, thereby improving the fill rate [5]. The company currently organizes its spare parts inventory using an inventory turnover ratio classification, where "moving codes" represent sales frequency—lower codes correspond to higher sales frequency.

Stockouts can have significant negative impacts on the company, including customer dissatisfaction and loss of potential sales [6][7]. The inability to fulfill spare part demands not only disappoints customers and risks them turning to competitors but also results in financial losses for the company. To address this issue, the company must develop a more effective inventory management strategy, particularly for spare parts classified as moving code 1 [8]. The frequent occurrence of stockouts highlights the company's suboptimal approach to forecasting market demand. Currently, its forecasting relies solely on historical data and qualitative analysis, which are less accurate than quantitative methods using mathematical models.

Moreover, the company's inventory policies require improvement, as the company lacks fundamental calculations for safety stock and reorder points. Safety stock serves as a buffer to minimize stockout risks, while the reorder point ensures timely spare part replenishment. This study focuses on enhancing the inventory management of moving code 1 spare parts by identifying the most suitable forecasting methods, such as Double Exponential Smoothing (DES), Weighted Moving Average (WMA), and Monte Carlo simulation. Additionally, the Continuous Review System (CRS) approach will be implemented to balance demand and inventory levels, aiming to achieve a target fill rate of 90% while preventing overstock and stockouts.

Therefore, this study will suggest a procurement planning strategy using Material Requirement Planning (MRP) combined with the Fixed Order Quantity (FOQ) technique, aligning with the company’s purchasing policy. By adopting these measures, it is anticipated that the company will enhance the availability of spare parts and significantly mitigate the risk of stockout.

II. RELATED WORKS

Several studies have explored various forecasting methods to enhance inventory management across different sectors. In [9], the Double Exponential Smoothing (DES) method is applied alongside trend analysis to project demand for maintenance box packaging, finding that DES significantly outperformed trend analysis in accuracy, thus aiding in inventory optimization.

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Similarly, [10] utilized DES to forecast motorcycle spare part stock, demonstrating its effectiveness in minimizing forecasting errors and preventing both excess inventory and shortages, which ultimately improves inventory management efficiency. In the context of building materials, [11] employed the Weighted Moving Average (WMA) method, which provided precise forecasting results, facilitating better procurement planning for CV. EDT Group. The research in [12] developed a WMA-based forecasting system for car spare part needs, achieving high accuracy in inventory planning and significantly reducing stockout risks. Additionally, [13] utilized the Monte Carlo method to predict frozen food sales at Supermama Frozen Food, effectively capturing demand patterns and enhancing stock planning, while [14] used Monte Carlo Simulation and compared it with the Trend Linear Line (TLL) method for hex nut sales forecasting, revealing that while TLL is suitable for linear trends, Monte Carlo offers superior accuracy in random demand scenarios, both improving sales planning precision.

The study aims to show a variety of forecasting and inventory management strategies tailored to the specific needs of the company, which making a significant contribution to operational efficiency and risk management.

Table 1. Quantity Data

No	Item	Demand (unit)	Supply (unit)	Stockout (unit)	Initial Inventory (unit)	Minimum Quantity Multiple Purchase	Storage Capacity (unit)
1	234011332L	37.979	19.666	18.313	509	25	1.425
2	156072190L	16.774	10.677	6.097	281	6	282
3	23304JAC70	16.884	12.459	4.425	633	20	800
4	493051110L	6.586	2.535	4.051	64	6	234
5	234011440L	9.383	6.690	2.693	29	20	300

III. DATA AND METHODS

A. *Data Collection*

To address the stockout problem in this study, various essential data were collected and analyzed. These data, related to spare part inventory management, were obtained from the company and processed into actionable insights and knowledge. The collected data include demand, supply, lead times, initial inventory levels, minimum order quantities (if purchase multiples), and storage capacities for each moving code 1 spare part item.

Demand and supply data were used to classify spare parts using ABC and HML analyses. Additionally, demand data were employed to forecast the future demand for selected moving code 1 spare parts over the next 12 periods. Initial inventory data represent the quantity of each spare part item stored in the warehouse at the beginning of a specific time period. This data, derived from inventory records at the end of the previous period, is crucial for creating a spare part ordering schedule using Material Requirements Planning (MRP). The minimum order quantity refers to the predefined batch size for each purchase, while the storage capacity of spare parts in the warehouse plays a key role in determining the timing and quantity of spare part orders. A summary of these data is provided in Table 1 (for item selected through classification process).

B. *Classification*

The implementation of classification in inventory management offers substantial advantages, enabling companies to concentrate on critical items and thereby develop an optimal inventory management strategy. Effective inventory management necessitates a systematic approach to establishing priorities and judiciously allocating resources [15].

In this study, we focus on spare parts classified under moving code 1, which comprises 278 distinct items. A classification process is essential to identify the specific spare parts within this category that warrant closer examination. By sorting and prioritizing these items, we can streamline the evaluation process. The classification method aids in reducing data complexity by grouping spare parts according to defined criteria, thus enhancing the decision-making process regarding which moving code 1 items to analyze further. This research employs two classification techniques: ABC analysis and HML analysis [16].

C. *Forecasting*

The forecasting process in this study employs three distinct methods: Double Exponential Smoothing (DES), Weighted Moving Average (WMA), and Monte Carlo Simulation (MCS). The method yielding the lowest Mean Absolute Percentage Error (MAPE) will be identified as the recommended approach for forecasting the demand for selected moving code 1 spare part items in the future. Furthermore, the results of this demand forecast will serve as a basis for determining the average annual demand, which is essential for calculating the safety stock value and reorder point using the Continuous Review System (CRS) approach, as well as for developing the Material Requirement Planning (MRP).

The Monte Carlo simulation involves several key stages, including the identification of probability distributions based on historical data parameters, random number generation, and the determination of the adequacy of the number of replications. Additionally, the simulation model will undergo validation, and the error rate of the forecast results will be assessed using MAPE [17]. This comprehensive approach ensures robust and reliable forecasting outcomes that can effectively inform inventory management decisions.

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D. Procurement Planning

Before scheduling an order, it is essential to calculate the safety stock (SS) and reorder point (ROP) using equations (1) to (4). The results of these calculations will be utilized to create an order schedule for five selected spare part items with moving codes over the next 12 periods. The order scheduling in this study is structured using Material Requirement Planning (MRP) combined with the Fixed Order Quantity (FOQ) lot sizing technique. The design of the MRP with the FOQ lot sizing approach necessitates comprehensive historical data, including forecasting data, lead time, reorder point values, initial inventory levels, minimum order quantities (if purchase multiples), and storage capacity. The forecasting data employed is derived from the method that yields the lowest Mean Absolute Percentage Error (MAPE) for each item.

$$DL = AD \times L \quad (1)$$

$$\sigma_{dLT} = \sigma_d \times \sqrt{L} \quad (2)$$

$$SS = z \times \sigma_{dLT} \quad (3)$$

$$ROP = DL + SS \quad (4)$$

where:
DL = Demand during lead time
AD = Average demand in 1 month
L = Lead time
σ_{dLT} = Standard deviation of demand during lead time
σ_d = Standard deviation of demand
z = z-score

In order to optimize inventory management, Material Requirement Planning (MRP) is an essential tool for managing and planning inventory more effectively [18]. MRP is designed to help companies make decisions regarding scheduling of material or component orders based on the company's specific needs, thereby preventing issues related to overstock and stockouts. It effectively operationalizes the company's safety stock and reorder point policies into actionable material ordering schedules. In utilizing the MRP system, it is essential to consider both the order quantities and the company's capacity for handling these orders.

When implementing MRP, the selection of lot sizing techniques is a vital consideration. Lot sizing determines the optimal number of units to be ordered in a single transaction (lot). For companies with a fixed minimum order quantity, the Fixed Order Quantity (FOQ) method is particularly suitable [19]. Once the ordering schedule is established, it is necessary to calculate the fill rate.

Fill rate serves as a performance indicator to evaluate the effectiveness of inventory management and can be calculated using equation (5). A high fill rate indicates that the company's inventory effectively meets customer demand, thereby enhancing customer satisfaction. Conversely, a low fill rate may indicate underlying issues in inventory management, such as stockouts, which can result in customer dissatisfaction, lost sales, and other detrimental effects on business operations. A fill rate is deemed low if it falls below 50%, while a rate of 90% or higher is considered high [20].

$$Fill\ Rate = \frac{Number\ of\ demands\ fulfilled}{Total\ demand} \times 100\% \quad (5)$$

Table 2. Classification and Forecasting Result

No	Item	% Kumulatif (investasi)	Hasil Klasifikasi *ABC Analysis*	% Kumulatif (stockout)	Hasil Klasifikasi *HML Analysis*	MAPE		
						DES	WMA	MCS
1	234011332L	23.41%	A	30,43%	H	20.87%	25.95%	26,07%
2	156072190L	4.90%	A	40,57%	M	12.96%	13.84%	14,03%
3	23304JAC70	15.27%	A	47,92%	M	17.40%	18.63%	21,70%
4	493051110L	29.50%	A	54,65%	M	31.71%	53.05%	27,95%
5	234011440L	18.34%	A	59,13%	M	17.16%	20.40%	22,49%

Tabel 3. Safety Stock and Reorder Point Calculation Result

Nilai	***Safety stock* dan *Reorder point***				
	234011332L	**156072190L**	**23304JAC70**	**493051110L**	**234011440L**
AD	2.923,50	1.446,33	1.515,00	463,75	721,50
L	0,25	0,25	0,25	0,25	0,25
DL	730,88	361,58	378,75	115,94	180,38
StdD	48,71	225,09	291,42	216,64	81,09
StdDL	24,36	112,55	145,71	108,32	40,54
Fill rate	0,90	0,90	0,90	0,90	0,90
Z	1,28	1,28	1,28	1,28	1,28
SS	32	145	187	139	52
ROP	763	507	566	255	233

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IV. RESULT AND ANALYSIS

A. *Classification and Forecasting Result*

The results of the ABC analysis classification contained in Table 2 indicate that out of 278 spare part items moving code 1 owned by the company, 80 spare part items fall into category A, 86 spare part items are classified as category B and 112 spare part items as category C.

Subsequently, the 80 spare part items classified as category A were further analyzed using the HML (High-Medium-Low) classification method. The HML analysis revealed that 1 spare part item was categorized as H (High), 4 items as M (Medium), and 75 items as L (Low). Items classified as category H require stricter supervision and management compared to those in the other categories. Although items in category M are not as critical as those in category H, they still necessitate careful oversight to mitigate the risk of stockout. Therefore, spare part items in both categories H and M should be prioritized for further evaluation regarding inventory management strategies, as shown in Table 2.

The forecasting process aims to estimate the demand for spare parts over the next 12 periods, reflecting the actual demand conditions within the company. In this study, three distinct forecasting methods were employed to predict the demand for moving spare part item code 1. The objective was not only to project future demand but also to identify the most effective forecasting method for each selected spare part item code 1, as indicated by the lowest Mean Absolute Percentage Error (MAPE) values.

As shown in Table 2, five spare part items classified using the ABC and HML methods were analyzed, along with the corresponding MAPE values for each forecasting technique applied in this research. The results indicate that the Double Exponential Smoothing (DES) method is the most effective for forecasting the demand of spare part items 234011332L, 156072190L, 23304JAC70, and 234011440L. In contrast, the Monte Carlo simulation method proved to be the most suitable for forecasting the demand of spare part item 493051110L.

B. *Procurement Planning*

The Continuous Review System (CRS) approach allows companies to continuously monitor inventory and reorder as soon as the inventory level reaches the predefined reorder point. Following the forecasting results of the selected moving code 1 spare part demand items, the safety stock and reorder point values for each item were calculated. In this study, the safety stock and reorder point values of the five selected moving spare part code 1 items were calculated using the same target fill rate of 90%. As suggested by [21], a fill rate of 90% provides a balance between stockout and overstock risks.

The results of the calculation of the safety stock value and reorder point for the selected spare part items are summarized in Table 3. Spare part items 234011332L and 234011440L exhibit relatively small safety stock values due to their low demand variability, as indicated by a lower standard deviation. This reflects stable demand patterns with minimal monthly fluctuations. In contrast, spare part items 156072190L, 493051110L, and 23304JAC70 require higher safety stock values to accommodate significant demand variability observed across months.

Interestingly, a smaller safety stock value does not always correspond to a lower reorder point. The reorder point incorporates the safety stock value to address unexpected demand but also factors in the average monthly demand and lead time. For example, although spare part item 234011332L has a smaller safety stock value than items 156072190L, 493051110L, and 23304JAC70, it has a higher reorder point due to its higher average monthly demand.

Furthermore, the order planning in this study was designed using Material Requirement Planning (MRP) with the Fixed Order Quantity (FOQ) lot sizing technique. MRP design will be adjusted from a monthly to a weekly scale, enabling the company to precisely determine when to place orders for spare parts. The result shows that in the 12-period order projection, spare part item 234011332L will be ordered 35 times, item 156072190L 48 times, item 23304JAC70 28 times, item 493051110L 29 times, and item 234011440L 36 times. Despite weekly orders being placed for spare part item 156072190L, the quantity ordered fails to meet the Gross Requirement and the predefined reorder point. This shortfall arises from the company's limited storage capacity, which restricts the volume of spare parts that can be ordered. Consequently, even when orders are aligned with the reorder point value and the minimum purchase multiple, the company's storage constraints hinder adequate inventory management.

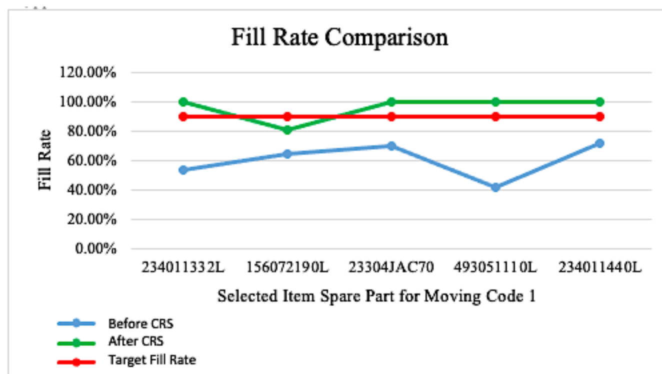

Figure. 1 Fill Rate Comparison

The comparison of fill rate calculations serves as a critical evaluation tool to assess the effectiveness of the Continuous Review System (CRS) approach implemented in this study to address stockout challenges in the company.

Fig. 1 illustrates the fill rate performance of five selected moving code 1 spare part items before and after implementing the Continuous Review System (CRS). The x-axis represents the spare part items codes, while the y-axis indicates the fill rate in percentage terms. The blue line represents the fill rate before the implementation of CRS, which ranges from approximately 50% to 70%. The green line shows the fill rate after CRS implementation, demonstrating a significant improvement, with most items achieving close to or exactly 100% fill rate. The red line indicates the target fill rate.

As illustrated in Fig. 1, there is a noticeable increase in the average fill rate following the adoption of the CRS. Key

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observations include that four out of the five items met or exceeded the target fill rate after CRS implementation. The spare parts that met or surpassed this target include 234011332L, 23304JAC70, 493051110L, and 234011440L. In contrast, the spare part item 156072190L only reached a fill rate of 80.31%, suggesting room for further improvement in that case. This shortfall can be attributed to its limited storage capacity, which falls below the predefined reorder point. Consequently, the insufficient inventory levels increase the likelihood of stockouts occurring before new orders can be fulfilled. To mitigate this issue, it is essential for the company to consider enhancing the storage capacity for spare part item 156072190L, enabling it to maintain adequate inventory levels in line with the reorder point and ultimately improve its fill rate.

Table 4. Fill Rate Improvement

No	Item	% fill rate improvement
1	234011332L	47.09%
2	156072190L	16.20%
3	23304JAC70	30.03%
4	493051110L	58.21%
5	234011440L	28.49%

In terms of percentage of fill rate improvement, Table 4 shows a substantial increase in fill rate across all items, indicating the effectiveness of the CRS approach in addressing stockout issues. The most substantial increase was observed for item 493051110L, with a 58.21% improvement. Similarly, item 234011332L demonstrated a notable improvement of 47.09%. Moderate improvements were seen for items 23304JAC70 and 234011440L, with fill rate increases of 30.03% and 28.49%, respectively. Meanwhile, item 156072190L exhibited the lowest improvement at 16.20%, likely influenced by its limited storage capacity, which constrained the optimization of its inventory levels.

In general, this figure emphasizes the effectiveness of the CRS approach in optimizing inventory management and reducing stockout risks, especially for items with high variability in demand. However, the relatively smaller improvement for item 156072190L suggests the need for additional strategies, such as expanding storage capacity, to fully optimize the fill rate for this particular spare part. Overall, the implementation of CRS has proven to be an effective method for improving inventory management and ensuring better demand fulfillment. Thus, the CRS approach is worthy of consideration by the company to be implemented in the inventory management of selected moving code 1 spare part items.

V. Conclusion

This study confirms that the Double Exponential Smoothing (DES) method with optimized α and β parameters effectively forecasts demand for spare parts 234011332L, 156072190L, 23304JAC70, and 234011440L over the next 12 periods. For items with high demand fluctuations, such as 493051110L, the Monte Carlo method is more suitable. Projected order frequencies for the next 12 periods are 35 times for 234011332L, 48 times for 156072190L, 28 times for 23304JAC70, 29 times for 493051110L, and 36 times for 234011440L.

The Continuous Review System (CRS) demonstrating a significant improvement, with most items achieving close to or exactly 100% fill rate. Although item 156072190L achieved only 80.31% due to storage limitations. The CRS approach proves effective for the company in addressing stockout issues and improving inventory management. Future research could focus on incorporating cost factors in order scheduling and extending the forecasting period to better capture seasonal patterns and improve demand accuracy.

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