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OPTIMIZATION OF SPARE PARTS INVENTORY USING THE MONTE CARLO APPROACH (CASE STUDY OF PT. SMART TBK, EAST KALIMANTAN)

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ABSTRACT : Inventory plays a crucial role in the supply chain and has a significant impact on a company's financial and operational performance. The substantial investment in inventory makes it one of the largest assets in the supply chain, with some companies holding inventory valued at over 25% of their total assets. The fluctuations in inventory activities often require careful control, particularly in the management of spare parts, which is a critical aspect of a company's operations. Ineffective management of spare parts inventory can negatively affect both financial performance and production. Therefore, optimal control is necessary to minimize the risk of excess or shortage of spare parts and to ensure optimal availability of these items. This study was conducted at PT. SMART, Tbk East Kalimantan, a publicly listed company operating in the palm oil plantation sector. The objectives of this research are to (1) determine the inventory parameters (s, S) for spare parts to achieve a desired availability level at an economical cost, (2) quantify the impact of changes in inventory parameters on service levels and the associated costs, and (3) evaluate the company's policies related to these costs. The Monte Carlo method was utilized in this study, considering the classification of spare parts into Fast, Normal, and Slow Moving categories. The results of the Monte Carlo simulation revealed the optimal total cost, and a sensitivity analysis indicated that changes in inventory parameters influence decision-making. In the final stage, forecasting was conducted to guide decision-making over the next five years.
KEYWORDS :*Monte Carlo, Spare parts, Forecasting, Simulation*

I. INTRODUCTION

Inventory is one of a crucial role in the supply chain and has a significant impact on a company's financial and operational performance (Anshur et al. 2019) (Mondol 2021). The large amount of investment in inventory makes it one of the largest assets in the supply chain. Some companies even have inventory values reaching more than 25% of the total value of their assets (Lukitosari et al. 2019). Inventory activities often experience fluctuations that require special control. Inventory needs to be controlled for both materials, semi-finished goods and products (Malindzakova and Zimon 2019) (Ngunyule 2020). One of the supplies that need to be controlled is spare parts. Spare parts do not have a direct effect but have an important role in the production process. The relationship requires collaboration between departments. This can be solved with spare part inventory management (HwangandSamat 2019).

PT. SMART, Tbk East Kalimantan is a public company and a major player in the plantation industry with a focus on sustainable palm oil production. Spare parts inventory management at PT. SMART, Tbk East Kalimantan faces major challenges in the effectiveness of spare parts inventory management. The excess or shortage of spare parts that occurs in PT. SMART, Tbk East Kalimantan currently has a significant impact on increasing costs and decreasing productivity. In addition, the inventory control process requires a classification of the materials or products stored. This is useful for the ease of analyzing and controlling the goods.

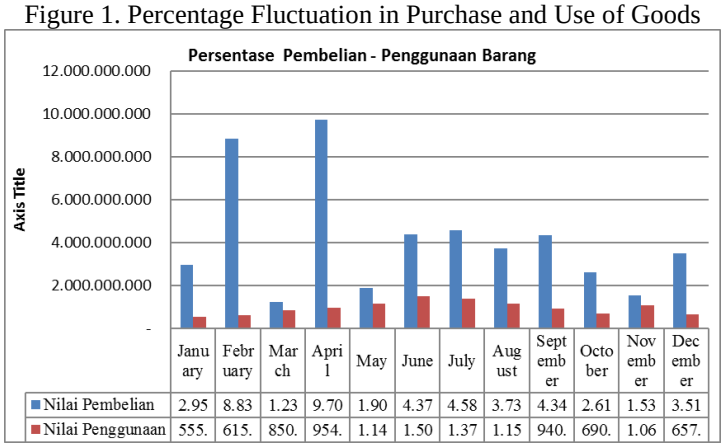
Several research related to inventory have been conducted by previous researchers. Research related to spare parts inventory control such as (Hwang and Samat 2019), (Zhang et al. 2022) and (Affonso et al. 2024). Meanwhile, other research related to the grouping of stored items has been conducted by (Gizaw et al. 2021) (Yusok and Alfadlani 2024).

This research focus to optimizing the sparepart inventory. Based on the background and previous research, a study was conducted related to spare parts inventory control. The study was conducted because of the fluctuating demand for use from other departments. The grouping of research objects was carried out using the FNS (Fast, normal and slow) method. The research objects are representatives of each grouping result. After being grouped, an analysis was carried out using the Monte Carlo method with microsoft excel.

II. LITERATUR REVIEW AND CASE STUDY

PT. SMART, Tbk East Kalimantan has operational activities that the company uses various equipment including heavy equipment units, tractors, and dump trucks to support palm oil production. One of the main activities is the transportation of Fresh Fruit Bunches (FFB) using HINO dump trucks with a load capacity of 5-10 tons. This transportation activity requires routine maintenance so that the HINO dump truck unit continues to operate optimally and prevents breakdowns that can hamper production. In maintaining the availability and optimal performance of the HINO dump truck unit, spare parts inventory is crucial. Spare Part is an item that consists of several components that form a single unit and have a specific function (Ginting 2021). In order to assist product maintenance and minimize downtime while extending product life, spare components are kept in inventory. The "right to repair" movement, which mandates that manufacturers keep an adequate supply of spare parts on hand for their entire product life cycle in order to minimize waste and ultimately achieve sustainability, has recently drawn increased attention to spare parts inventory management (Zhang et al. 2021). The need for these spare parts is regulated by each head workshop and involves the procurement process and management in the warehouse. Purchase of HINO spare parts is divided into two categories, namely Regular goods and VHS (Vendor Held Stock) goods, Vendor Held Stock is a popular supply chain optimization strategy for gas, oil, and renewable energy resources. It extends the idea of Vendor Managed Inventory on the Consignment Model, where the vendor offers additional procurement, delivery, and storage and inventory management services (Heitasari et al. 2024). VHS goods have been determined and agreed upon by the first and second parties, there are around 300 VHS item lists and the creation of VHS Purchase Orders is done once for three months of the validity period of the PO and if it is not on the VHS list then the goods or spare parts are included in the Regular part category. Storage of VHS goods inventory is in a warehouse managed by the vendor and is located at a plantation location provided by PT. SMART, Tbk East Kalimantan when the user needs VHS goods, the user will go to the vendor's warehouse and take the goods according to the PO number issued by procurement and for regular goods will be stored directly in the first party or company warehouse if the goods have arrived. PT. SMART, Tbk East Kalimantan faces serious challenges in inventory control, especially related to the instability of purchasing and usage of goods during 2023 as show on figure 1.

Figure 1. Percentage Fluctuation in Purchase and Use of Goods



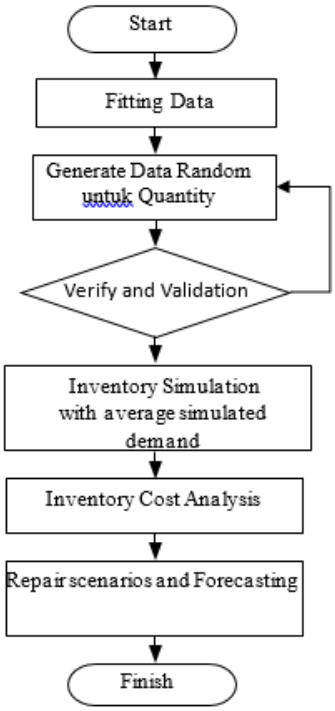
	January	February	March	April	May	June	July	August	September	October	November	December
Nilai Pembelian	2.95	8.83	1.23	9.70	1.90	4.37	4.58	3.73	4.34	2.61	1.53	3.51
Nilai Penggunaan	555.	615.	850.	954.	1.14	1.50	1.37	1.15	940.	690.	1.06	657.

This condition not only creates financial losses, but also raises risks that can affect the availability and smoothness of operations. To overcome this problem, researchers plan to conduct research that focuses on developing a spare parts inventory control system.

III. METODHOLOGY

Spare parts with unstable demand are the focus of the research, and the base-stock periodic review model will be implemented to design a more effective inventory management strategy. In addition, the Monte Carlo simulation method will be used to improve the spare parts inventory parameters by first grouping them with the FNS (Fast, Normal, Slow Moving) system to identify and group spare parts based on movement speed or demand level (Ananyev et al. 2019) (Gilbert 2023). This approach will provide a foundation for more focused and efficient inventory management.

Figure 2. Monte Carlo Flowchart

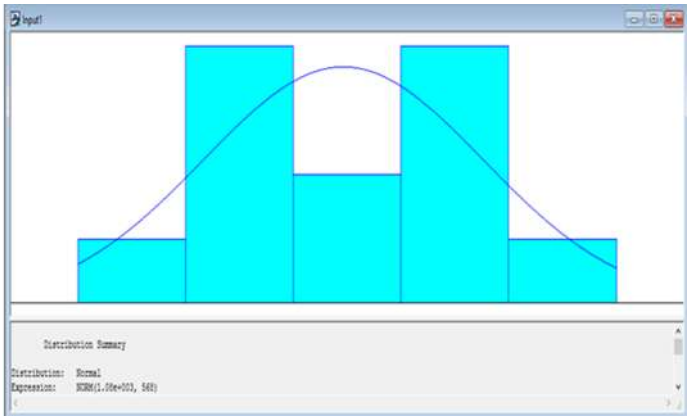


IV. RESULTS AND DISCUSSION

The processed spare parts data is a sample data from several FNS groups that will be used as research objects. The sample data is based on the history of usage in the period 2023. Data processing is carried out by analyzing material usage, by determining procurement costs considering the history of spare part usage. The next step is to conduct an analysis to determine the strategy for fulfilling spare parts needs. The simulation carried out is influenced by several cost aspects such as holding costs and order costs. The steps of Monte Carlo simulation with the example of spare part No. Material 10074963 are as follows:

a. Choose minimal one sample in any type of FNS group spare part
b. Fitting the demand data distribution using Arena software.

Figure 3. Fitting Data Distribution Part 10074963



c. Generating random numbers using the generate random feature in Microsoft Excel ('=rand')
d. Calculating simulated demand by referring to random numbers based on the distribution model obtained fromexcel and Arena software
e. Performing replication by generating random numbers ten times, then performing calculations as in step 3 for each replication
f. Calculating the average of the simulated demand results from the ten replications to obtain the simulated demand value that will be used in making purchasing decisions

g. Validating and validating to see the suitability of the model to real conditions
h. Determining input variables (Q*,SS, S, s)
i. Conducting Monte Carlo simulations to use predetermined variables
j. Calculating the associated costs of each predetermined purchasing decision from repair scenario such as table 2.

Table 2. Decision Part 10074963

Period	Stock Awal	Receipt	Total Stock	Demand	Shortage	Last Stock	s	S	Order	Decision (I/o)
Jan. 2023	0	0	0	1136.821	1136.821	0	2015	2480	2433.5	1
Feb. 2023	0	2433.5	2433.5	1065.319	0	1368.181	2015	2480	1065.319	1
Mar. 2023	1368.181	1065.319	2433.5	812.3449	0	1621.155	2015	2480	812.3449	0
Apr. 2023	1621.155	0	1621.155	1283.241	0	337.9137	2015	2480	2095.586	1
Mei. 2023	337.9137	2095.586	2433.5	799.2912	0	1634.209	2015	2480	799.2912	1
Jun. 2023	1634.209	799.2912	2433.5	1122.5	0	1311	2015	2480	1122.5	1
Jul. 2023	1311	1122.5	2433.5	1434.055	0	999.4446	2015	2480	1434.055	1
Agu. 2023	999.4446	1434.055	2433.5	1296.822	0	1136.678	2015	2480	1296.822	1
Sep. 2023	1136.678	1296.822	2433.5	914.4236	0	1519.076	2015	2480	914.4236	1
Okt. 2023	1519.076	914.4236	2433.5	985.8718	0	1447.628	2015	2480	985.8718	1
Nov. 2023	1447.628	985.8718	2433.5	1032.994	0	1400.506	2015	2480	1032.994	1
Des. 2023	1400.506	1032.994	2433.5	1173.233	0	1260.267	2015	2480	1173.233	1
Total Cost				13,057	1,137	14,036			15,166	11

Inventory costs can consist of storage costs, ordering costs and shipping costs (Engebrethsen and Peres 2019) (Shaikh et al 2019). In this study, shipping costs were used because they are the vendor's responsibility. In the analysis process, costs arising from the procurement process are looked at, namely ordering costs and spare part storage costs. In this study, shipping costs were not used because this is the vendor's responsibility.

Storage cost (Rp) = Number of stock x Holding cost
= 14.036 × 50
= 701.800
Ordering cost (Rp) = Number of orders × Order cost
= 11 × 5,000
= 55.000
Total cost = 701.800 + 55.000
= 756.800

The results of the selected improvement simulation show that by reducing ROQ by 10%, costs with inventory cost Rp 756.800 from Rp 85.600 in existing condition. The cost increase occurs because by reducing ROQ by 10% it will increased the amount of optimum inventory stored. This is because the storage cost is higher than the ordering cost. The final cost of each type of spare part is shown in table 3.

Table 3. Inventory Cost Sparepart

Sparepart ID	Category	Cost Existing	Cost Final Decision
10074963	Fast	Rp 85.600	Rp 756.800
10076095	Fast	Rp 54.850	Rp 18.900
10098848	Fast	Rp 26.850	Rp 13.700
10109896	Normal	Rp 35.200	Rp 15.750
10088548	Slow	Rp 37.300	Rp 42.000

In spare part 10076095, the optimal inventory cost decreases from the existing condition, which is from Rp 54,850 to Rp 18,900. This occurs because by reducing ROQ by 10%, the number of orders and the total spare parts stored decreases. Spare part ID 10088548 also decreases to Rp 13,700 from Rp 26,850. Furthermore, spare part 10109896 experiences the same change, decreasing to Rp 15,750 with a 50% increase in ROQ. Unlike the previous three spare parts, spare part ID 10088548 experiences a 30% increase in ROQ.

A fluctuating inventory requires control for future planning. Future planning can be done by forecasting. In this study, forecasting was done for the next five years with the assumption of a 10% increase in demand. The forecasting results for the five types of spare parts are as follows.

Table 4. Forecasting Inventory Cost Sparepart

Sparepart ID	Total Cost	Total Order
10074963	693.150	11
10076095	18.900	2
10098848	18.600	3
10109896	15.000	1
10088548	32.500	3

Based on table 4, there are forecasting results for spare part procurement in the fifth year after the year of implementation of the improvement plan, namely 2029, showing that spare part 10074963 costs Rp693,150 for one inventory period with a total of 11 orders. While spare part ID 10076095 reaches a total cost of 18,900 for storage and ordering 2 times in one period. Spare part ID 10098848 costs 18,600 for 3 orders. Spare part 10109896 costs 15,000 for one period while spare part 10088548 costs 325,000 for one period.

V. CONCLUSION

Based on the analysis and research findings, it can be concluded that the Monte Carlo method successfully determined optimal inventory parameters, such as ROP and ROQ, adjusted based on the FNS (Fast, Normal, Slow Moving) spare part categories. The simulation demonstrated cost efficiency with a 10% reduction in ROQ, despite an increase in storage costs for certain cases. A five-year forecast, assuming a 10% increase in demand, provided strategic guidance to mitigate the risks of inventory shortages or surpluses. Furthermore, improved inventory management can reduce operational costs and enhance company productivity. This approach can increase the operational efficiency and productivity of PT. SMART, Tbk East Kalimantan.

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