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Optimalization of Spare Part Inventory Management: Case Study at PT XYZ

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ABSTRACT

The purpose of this study is to evaluate the causes behind PT XYZ's inadequate spare parts inventory management. This study uses a case study with a problem diagnosis approach as its methodology. Interviews were used to obtain the research data. Five decision-making phases are used as a conceptual framework for the analysis of the interview data. Industrial managers are guided by these five steps in managing actual spare parts in their organizations. The findings from this study reveal that the company has not fully optimized each stage, resulting in continued inefficiencies in inventory management. By identifying these issues, the suggested improvements are tailored to the specific challenges faced at each stage, making them applicable for implementation in inventory management to achieve greater effectiveness. This study concludes that PT XYZ's spare parts inventory management inefficiencies stem from weaknesses across all five decision-making stages. The proposed solutions include: (1) implementing a standardized numbering system combining part classification, serial number, and storage location; (2) adopting VED (Vital, Essential, Desirable) classification based on criticality; (3) applying statistical forecasting methods such as lead-time demand analysis to determine reorder points and safety stock; (4) developing data-driven stock management policies aligned with part classification; and (5) establishing regular policy evaluation through simulations and cross-divisional discussions.

INTRODUCTION

A company that aims to achieve maximum profitability requires the support of various stakeholders to ensure that its business activities run effectively, among them are customers and suppliers. In the current competitive environment, corporate focus is increasingly viewed from the customer's perspective, compelling management to meet customer needs while maintaining long-term relationships with existing clients. To achieve this, companies strive to establish partnerships or strategic collaborations with suppliers, distributors, and other firms that possess similar capabilities. This approach has proven effective in maintaining business

success, as the products or services delivered to customers can be distributed efficiently and effectively. Such an approach represents an impflementation of supply chain management (SCM) within the company.

According to Simchi-Levi et al. (2000), as cited in Khan and Yu (2019), supply chain management is defined as a comprehensive set of approaches used to efficiently integrate all partners within the supply chain—including suppliers, manufacturers, warehouses, and stores—so that products are produced and distributed in the right quantities, to the right locations, and at the right time, with the goal of minimizing system-wide costs while meeting expected service-level requirements. The objective of this management system is to establish a supply chain that maximizes its competitive advantage and provides benefits to both customers and the company itself (Heizer, Render, and Munson 2019)

To achieve these objectives, several conditions must be met, such as maintaining excellent customer service while controlling inventory investment through effective purchasing (Hastings 2021). In the modern business environment, the fundamental goal of companies in managing their supply chains is not merely to satisfy customers but to delight them (Khan and Yu 2019). This goal can be achieved by carefully managing the key components of the supply chain, which is inventory management.

Operational managers generally recognize that inventory management plays a crucial role in the supply chain. Inventory represents a significant component of a company's financial statements (Heizer et al. 2019). The success of inventory management depends heavily on the policies adopted, as these influence how efficiently a company utilizes its assets in producing goods and services (Shah, Mittal, and Cárdenas-Barrón 2021). Developing an effective inventory control system that minimizes stockouts and waste is a complex challenge for both service and manufacturing companies. This issue is also experienced by PT XYZ, a service company that serves as the object of this research.

Based on preliminary interviews with PT XYZ's operational manager, it was revealed that in 2021, expenses for local and imported spare parts accounted for approximately 32% of the company's total operating costs. For the general manager, this figure indicates inefficiencies in inventory management, which in turn reduced the company's profitability. Furthermore, customer dissatisfaction has arisen due to lengthy unit repair times, which negatively affect clients' operational activities. Another issue identified was inaccuracies in inventory recording, as the data entered the system often did not match physical stock counts (Table 1). During stock opname (inventory checks), discrepancies were frequently found between physical inspections and system records, resulting in unreliable spare parts data and consequently reducing the accuracy of financial reporting.

Table 1. Sample of Duplicate Spare Parts Inventory Names

Item Code	Item Description
Shelf 18 ~ 9187423-00	Back Buzzer
5241705-95	Back Buzzer
080674	Socket SB 175 Grey (Unused)
08072	Socket SB 175 Grey (Imported)
17967469	Socket SB 175 A Grey

The importance of inventory management is also reflected in the study conducted by Yapono (2021), which identified inventory problems among ornamental plant micro, small, and medium enterprises (MSME X). In that case, incomplete inventory planning for high-demand plants often resulted in stock shortages when buyers arrived. The study recommended improving inventory management using forecasting methods such as moving average, SKU management, safety stock, and reorder point.

Inventory-related issues have also been examined in Lestari (2012) research, which found that the company under study did not conduct inventory forecasting based on customer demand nor account for costs associated with ordering. The study recommended the application of the Economic Order Quantity (EOQ) method, although its results were suboptimal because inventory costs were dominated by storage expenses, influenced by purchasing volume and frequent changes in supplier pricing. These factors rendered the EOQ calculation less relevant.

A different concept was applied in a study by Kusrini et al. (2019), which analyzed inventory management using the performance attributes of the Supply Chain Operations Reference (SCOR) model developed by the American Production and Inventory Control Society (APICS) in 2017. The study successfully evaluated the performance of an MSME engaged in sportswear production but found that the company scored poorly on the cost and asset management efficiency attributes, measured by inventory days of supply and capacity utilization.

Armenius (2020) stated that inventory management models are generally classified based on the type and characteristics of the inventory, categorized into dependent demand and independent demand. This study focuses on identifying the implementation of inventory management under the independent demand category, specifically spare parts. The conceptual framework used to identify related issues is the Five Decision-Making Steps developed by Cavalieri et al. (2008).

The urgency of this research stems from multiple factors. PT XYZ's spare parts expenses constituting 32% of operating costs represent a substantial financial burden requiring immediate attention. Customer dissatisfaction due to extended repair times threatens long-term business sustainability in a competitive rental

market. Inventory recording inaccuracies compromise financial reporting reliability and operational decision-making. Furthermore, the heavy equipment rental industry's reliance on efficient spare parts management for maintaining rental unit availability makes inventory optimization a strategic priority. Addressing these challenges requires systematic diagnosis of underlying problems and development of targeted, implementable solutions.

The conditions and business characteristics of PT XYZ differ from those of previous research objects; therefore, a problem diagnosis method is employed to address the specific implementation challenges observed. Cavalieri et al. (2008) designed a step-by-step decision-making framework to guide industrial managers in managing Maintenance, Repair, and Overhaul (MRO) spare parts in a practical and structured manner (Figure 1).

Figure 1. The Five Decision-Making Steps

RESEARCH METHOD

This study employed a case study approach. This research adopted an evaluative case study design, aiming to examine the spare parts inventory management methods implemented by PT XYZ and identify the weaknesses in the existing practices. The research process is illustrated in Figure 2.

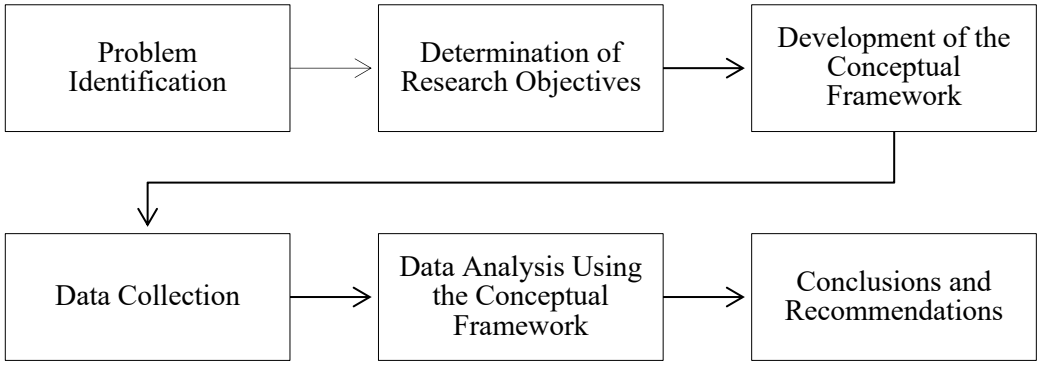

Figure 2. Research Stages Scheme

This study relied on both textual and visual data and applied a distinctive analytical approach utilizing multiple qualitative procedures (Creswell and Creswell 2023). Data were primarily collected through interviews. Sekaran and Bougie (2020) categorize interviews into two types: structured and unstructured. This study employed semi-structured interviews, with questions developed based

on the Five Decision-Making Steps framework and supported by relevant literature on inventory management.

The interview participants consisted of the operational manager, warehouse head, purchasing head, and accounting head. These individuals were selected because they collaborated directly with the warehouse division in daily operations and were therefore considered capable of providing informed insights regarding warehouse performance. Moreover, each participant possessed more than five years of experience in their respective positions. The responses obtained from the interviews served as the primary data source for this research. The selected participants were directly involved in daily business processes, enabling the study to gain an in-depth understanding of operational practices and managerial challenges related to spare parts inventory management.

RESULT AND DISCUSSION

Efficient and effective spare parts inventory management is crucial in complex and technologically advanced systems, as it plays a vital role in maintenance and repair activities (Kulshrestha, Agrawal, and Shree 2024). When efficiency is achieved, proper inventory management can help companies attain profitability, enhance customer loyalty, and promote business sustainability. Additionally, well-managed inventories contribute to reducing downtime, improving customer satisfaction, and establishing a competitive advantage over other market players.

However, the process of managing inventories presents various challenges, including demand uncertainty, unpredictable lead times, excess inventory, customer expectations, and decision-making regarding stock storage and replenishment. According to the framework developed by Cavalieri et al. (2008), there are five stages that serve as guidelines for identifying and improving inventory management practices.

Spare Parts Numbering System

In the first stage, each spare part should be assigned a unique identification number to facilitate retrieval and ensure traceability. An effective numbering system should also represent the technical characteristics and function of the part. Moreover, accurate numbering enhances the reliability of data recorded in the company's Accounting Information System (AIS).

Mardi et al. (2023) found that AIS has a significant positive influence on inventory control, meaning that the better the implementation of the AIS, the stronger the resulting internal inventory control. Cavalieri et al. (2008) do not prescribe a specific numbering format, as this should be tailored to the type of spare parts used in each organization. Yunita and Palit (2020) suggest using the Group

Technology concept, in which spare parts components are grouped through classification and coding methods. This approach categorizes spare parts into families based on shared attributes and assigns codes that symbolize their characteristics.

Based on interviews with PT XYZ's warehouse head, the current numbering system for spare parts does not yet follow a standardized format agreed upon by the warehouse staff. Therefore, it is essential for the warehouse division to develop and formalize a mutually agreed numbering format to ensure accurate and reliable inventory records within the system. Li and Tian (2008) proposed that code or numbering design should adhere to several key principles: uniqueness, scalability, applicability, standardization, and simplicity. Based on these principles, the numbering format for PT XYZ's spare parts inventory could be constructed using a combination of part classification, serial number, and storage location.

Table 2. Proposed Spare Parts Numbering Format

No.	Item Code	Item Name	Category	New Item Code
1	Shelf 81~5243178-17	BOARD ASSY	Vital	V - 5243178-17 – Shelf 81
2	SCR5	Charger PPT 24 V DC 50 A 1 phasa	Essential	E - SCR5 – Shelf 50
3	0814964	Bearing Roller Mast Heli 3 ton / Bearing release 55 x 119 x 34	Desirable	D – 0814964 – Shelf 24
4	3DCS	Battery GS Yuasa 3DCS465 48V	Essential	E - 3DCS – Shelf 45
5	FKEU-04	Solid Tire FKEU-04 700 - 12	Vital	V - FKEU-04 – Shelf 90

Spare Parts Classification

The second stage involves the classification of spare parts, which can be analyzed from several perspectives—financial, logistical, and maintenance (Cavalieri et al. 2008). Classification helps management prioritize procurement decisions and allocate resources effectively. In a literature review by Bhalla et al., (2021), several criteria were identified for classifying spare parts, including criticality, supplier availability, cost, and preventive maintenance schedules, among others. These criteria should be adapted to the company's business processes to ensure that classification accurately reflects operational needs. Interviews revealed that PT XYZ's spare parts classification has not been fully optimized. According to the warehouse head, approximately 500 purchase requests are submitted to the purchasing division each month, most of which are based on urgency and preventive maintenance schedules.

Referring to Dekker in Cavalieri et al. (2008), criticality-based classification can be used to determine which spare parts require closer monitoring and should be kept in stock to ensure production continuity. In practical terms, two classification methods can be applied: quantitative and qualitative. Quantitative methods use numerical drivers, such as demand value, and are typically based on Pareto's principle, such as the ABC analysis. Muniz et al. (2021) explain that the ABC method classifies items into three groups—A, B, and C—based on annual demand and purchase value. Qualitative methods, by contrast, rely on expert judgment or scoring methods to assess the criticality of spare parts, considering factors such as cost, downtime impact, and storage constraints. One commonly used qualitative method is the VED system (Vital, Essential, Desirable).

According to Teixeira et al. (2017), spare parts can be categorized into Vital, Essential, and Desirable components:

1. Vital parts are indispensable for the continuation of production or service activities.
2. Essential parts play an important but not critical role, affecting efficiency rather than continuity.
3. Desirable parts are low-risk items whose absence does not significantly impact operations.

Nirmala et al. (2022) noted that the risk levels in the VED method are divided into high, medium, and low categories, determined by factors such as lead time, supplier location, customization, and unavailability status (Shenoy 2018).

Currently, PT XYZ classifies its spare parts simply as fast-moving and slow-moving items. Most fast-moving spare parts are used for rented forklifts that operate in warehouses or factories for more than 12 hours per day, sometimes up to 24 hours. Since these forklifts are critical for clients' operations, the spare parts supporting them are prioritized. Slow-moving parts, although less frequently used, remain important for maintenance continuity.

To improve accuracy, PT XYZ should adopt the VED method and tailor the classification to the specific types of forklifts rented to customers.

Table 3. Spare Parts Classification Based on the VED Method

No	Item Name	Category	Function/Role
1	Battery Thailand / Lifttop VTFL 280	Vital	Provides power to operate the forklift engine
2	Charger 280 72 V 100 Ah (CB 3 Ton)	Essential	Recharges the forklift battery used in operations
3	Controller Neos	*Vital*	Serves as the electrical control center for forklift movement
4	Bearing Roller Mast Heli 3 ton / Bearing release 55 x 119 x 34	*Desirable*	Reduces friction and wear on machine components

5	Power steering motor 48 V	*Essential*	Facilitates easier and smoother steering control
6	Sensor speed	*Desirable*	Measures forklift movement speed

Spare Parts Demand Forecasting

The third stage focuses on forecasting demand for Maintenance, Repair, and Overhaul (MRO) spare parts. Accurate forecasting ensures that required parts are available when needed, minimizing downtime and maintaining operational efficiency. Two key forecasting approaches are commonly applied:

1. Reliability-Based Forecasting used when the condition and performance of equipment are known.
2. Time Series-Based Forecasting used when only historical usage data are available.

PT XYZ currently performs limited forecasting, primarily monitoring whether fast-moving spare part stocks fall below minimum levels. Warehouse staff coordinate with the after-sales division to anticipate technician visits and prepare purchase requests accordingly.

However, the company could improve forecasting accuracy by applying non-parametric statistical models. Boylan and Syntetos (2008) describe the Lead-Time Demand (LTD) approach developed by Willemain et al. (2004), which predicts total demand during the lead time between order placement and delivery. Accurate LTD forecasting is essential for determining reorder points and safety stock levels to avoid stockouts or overstocking.

The Reorder Point (ROP) formula (Heizer et al., 2019) is as follows:

$$\text{ROP} = (d \times L) + SS$$

Where:

1. ROP = Reorder Point
2. d = Demand
3. L = Lead time
4. SS = Safety stock

For example, if PT XYZ uses 50 plates per day with a lead time of five days and maintains a safety stock of 10%, the reorder point is reached when stock falls to 264 units.

Stock Management Policy

The fourth stage aims to establish stock management policies for MRO spare parts. The main objective is to determine the optimal stock level that balances availability and cost efficiency. This stage involves developing inventory strategies aligned with part classification, identifying which items must always be available, and determining minimum stock levels. Factors influencing these policies include

spare part demand, repairability, and warehouse structure (centralized or decentralized).

Currently, PT XYZ operates seven warehouses, with the main facility at the headquarters and smaller branch warehouses storing frequently used parts. The warehouse head stated that the central warehouse alone manages around 2,000 items per month, primarily for preventive maintenance. Management must periodically review which spare parts should be imported (for new rental units or repairs) and which can be locally sourced as substitutes. In urgent situations, the purchasing division often seeks equivalent-quality local alternatives to replace imported parts from Japan.

Policy Evaluation and Simulation

In the fifth stage, Cavalieri et al. (2008) emphasize the importance of testing and validating inventory management policies through simulations to ensure their practicality and effectiveness. This process involves selecting appropriate test scenarios, verifying policy assumptions, and correcting any detected errors. Such simulations help improve policy accuracy and mitigate potential operational risks. PT XYZ's management can perform evaluations by holding periodic discussions between the operational manager and warehouse staff to identify recurring warehouse issues that hinder operations. Simulations can also model stock downtime scenarios—situations where certain parts are unavailable—to analyze the potential impact and validate policy resilience.

CONCLUSION

Based on the findings and discussion, this study concluded that weaknesses were identified at each stage of the selected conceptual framework, indicating that spare parts inventory management at PT XYZ had not been fully optimized. These deficiencies could be addressed through several improvements, including enhancing warehouse staff competence—particularly their product knowledge of stored spare parts—through workshops involving the engineering and warehouse divisions to discuss spare parts catalogs, their functions in forklift units, and recurring operational issues. In addition, the warehouse division should conduct a more comprehensive analysis of spare parts demand and classification by considering factors such as the number and condition of rented units, supplier quality, order timing, and usage frequency. Management is also advised to regularly evaluate the implementation of Standard Operating Procedures (SOPs) related to spare parts inventory management and take prompt corrective actions when issues arise. As this study focused on a single service company in the forklift sales and rental sector, future research could expand the scope to other industries, such as manufacturing, include perspectives from additional internal divisions and branch

offices, and examine other inventory components beyond spare parts to provide a more comprehensive understanding of inventory management practices.

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