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Inventory Analysis at the Inspection Services Division using Economic Order Quantity (EOQ) and Just in Time (JIT) Approach

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ABSTRACT

In today's highly competitive business environment, companies strive to satisfy customers by delivering high-quality products and services. This holds true for a cargo inspection services company, which relies on procuring raw materials and equipment to ensure optimal service delivery. One crucial aspect of efficient operations is monitoring and controlling the inventory of cans used for sampling. Effective inventory control is essential to avoid excessive or insufficient stock levels, which can result in increased costs. To address this challenge, the company conducted research comparing different inventory control methods: Economic Order Quantity (EOQ) and Just-in-Time (JIT). The objective was to identify the most suitable approach to optimize inventory levels while minimizing costs. By implementing the JIT method, the company was able to determine the precise amount of materials needed, leading to an optimized inventory level. The analysis revealed that implementing JIT resulted in significant cost savings, totaling IDR 2,818,611,323. Based on these findings, it was concluded that the JIT method is the most appropriate inventory control approach for the Inspection Services Division. By adopting JIT, the company can effectively manage inventory levels, reduce costs, and enhance operational efficiency.

Key Words: Economic Order Quantity (EOQ), Just-in-Time (JIT), Inventory Control, *Sampling Technique.*

1. INTRODUCTION

The Business Competition Supervisory Commission (KPPU) for the 2022 period released its annual report and the results show that Indonesia's business competition index in 2022 is considered to be at the level of 4.82, the highest in the last five years. The index shows a slightly high level of business competition. Therefore a company must be able to face tough competition with other companies in order to survive in the market. To be able to compete, companies must be able to satisfy customers by providing good and optimal service quality, besides that the price offered is in accordance with the quality provided. The company's activities are inseparable from the existence of a tool inventory system that will be used to support business operations. A company needs to stock up on raw or supporting materials so that it can provide the best quality services (1-15).

The company, as an independent cargo inspector, must ensure strict supervision of materials throughout the inspection process to maintain quality and quantity compliance with regulations and distribution requirements. Supporting instruments, such as cans used for sampling, are crucial in this process. These samples serve as a reference for both the consignor and consignee of traded cargo and act as retain samples in case of future cargo claims. The company uses two types of cans, 4-liter and 1-liter volumes, specifically designed for storing oil (crude oil and product oil) and made of aluminum. These cans are ordered from vendors with whom the company has collaborations. Effective monitoring and control of can inventory is essential for the efficient delivery of inspection services to clients, as the amount of inventory directly impacts the smooth execution of inspection activities (16-17). However, the company has encountered several problems in managing the inventory of sample cans. The fluctuating demand

from clients has led to uncertainties in the required quantities, resulting in excess or insufficient stock. These situations have caused losses, such as unexpected purchases or increased storage costs (18-26). Additionally, the expensive cost per order for sample cans has posed a challenge in inventory management. Without proper inventory control, the irregular ordering frequency has led to erratic costs associated with placing orders. To address these issues, it is crucial to establish an inventory control system. By implementing such a system, the company can regulate the inventory of sample cans more effectively. This system will help optimize stock levels, reduce losses, and ensure a smoother supply chain process. The following Figure 1 illustrates the Total Cost of purchasing sample cans in the years 2020, 2021, and 2022, before the implementation of an inventory control system:

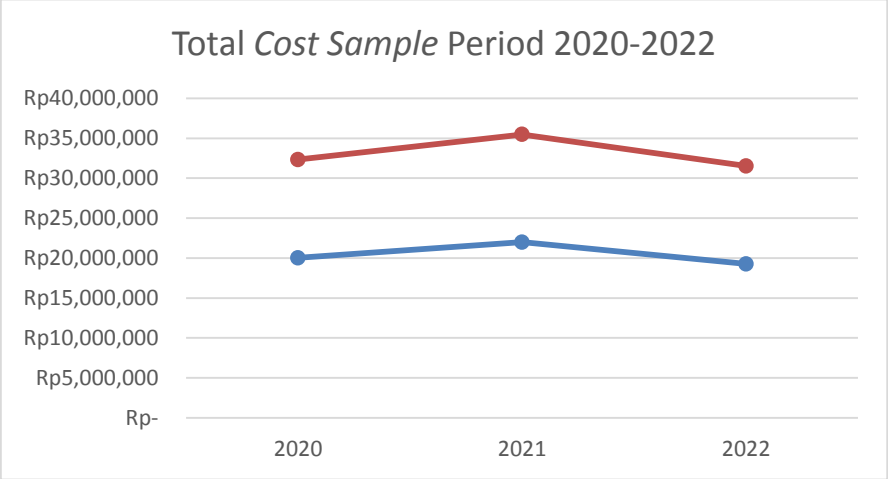

Fig 1 Total Cost Sample

The inventory control problems faced by the company have impacted various aspects, including the quantity of materials to be purchased within a specific period, the quantity of materials to be purchased per order, the frequency of placing orders, and the maintenance of a safety stock to avoid stock shortages and service delays. Sample cans are critical items used in servicing each client, making the efficient movement of sample can stocks crucial. The following data in Figure 2 illustrates the usage of sample cans during the period of 2020-2022:

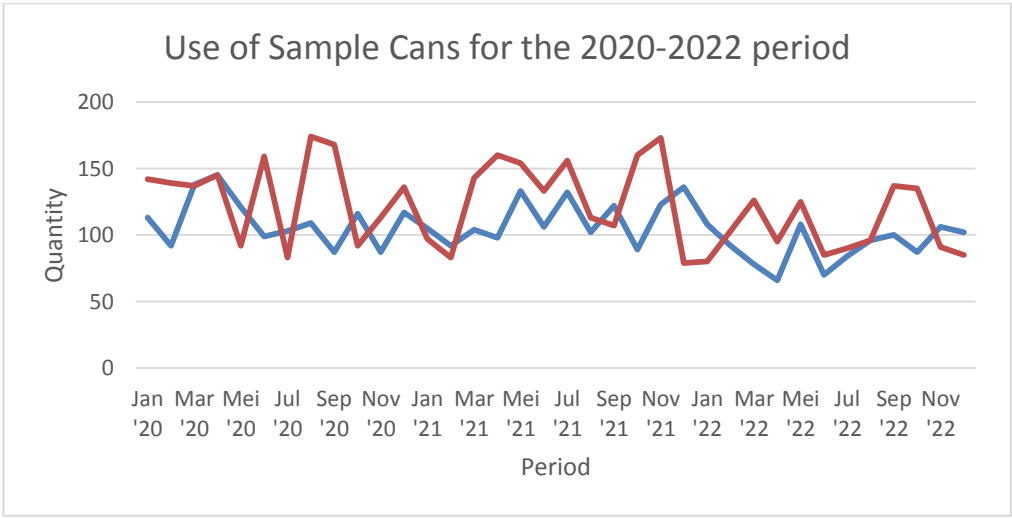

Fig 2 Sample of Cans

The efficient operation of a company relies on the availability of tools necessary to support its operations(27-31). It is crucial to ensure an adequate quantity of these tools to meet operational needs optimally. Insufficient stock levels can result in operational disruptions and missed opportunities for profit, leading to unexpected costs(32-34). On the other hand, excessive stock can lead to unnecessary storage expenses. Therefore, effective planning and control of inventory are essential to maintain sufficient stock levels, prevent shortages or excess, and minimize storage costs. To

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achieve this, various inventory control methods can be employed. In this study, two methods, namely the Economic Order Quantity (EOQ) method and the Just-in-Time (JIT) method, will be utilized(35-36). The EOQ method determines the most cost-effective order quantity for raw materials, considering minimum costs and reorder timings. By using EOQ calculations, stock outs can be minimized, resulting in cost savings and improved inventory storage efficiency. On the other hand, the JIT method is an inventory management approach that focuses on purchasing materials in the required quantities and at the right time, precisely when they are needed for production or operational activities(37-38). JIT calculations aim to streamline timing and minimize purchasing costs. By implementing these inventory control methods, the company can optimize its inventory management, improve operational efficiency, and reduce costs associated with stock outs or excessive stock levels.

2. RESEARCH METHOD

After data collection has been completed and complete, the data obtained will be used as material for analysis in inventory control of sample cans. Inventory control is carried out using two methods, namely the EOQ and JIT methods with the following data processing and analysis methods:

1. EOQ and TIC (Total Inventory Cost) Methods

Economic order quantity using the EOQ formula:

$$\text{EOQ } (Q^*) = \sqrt{\frac{2.D.S}{H}} \quad \ldots\ldots (1)$$

$$\text{TIC} = \left(\frac{D}{Q} \times S\right) + \left(\frac{Q}{2} \times H\right) \quad \ldots\ldots (2)$$

Information:

EOQ = Optimal number of items per order (Q*)
TIC = Total inventory control (total inventory cost)
D = Annual demand for inventory in units
S = Cost of installation or ordering of each order
H = Holding or holding cost per unit per year

The frequency of ordering raw materials based on the method can be calculated by the formula:

$$I = \frac{D}{EOQ} \quad \ldots\ldots (3)$$

Information:

I = Frequency of ordering materials
EOQ = Optimal number of items per order (Q*)
D = Annual demand for inventory in units

2. Safety Stock

Safety stock is a minimum amount of material inventory and must be owned by the company to guard against possible delays in the arrival of these materials or excess number of requests, so that stagnation does not occur. Determination of safety stock or Safety Stock is influenced by the relationship between Lead Time and Demand (demand). Calculation of safety stock in this study was carried out based on demand uncertainty. The formula used is:

$$\text{Sdl} = \text{Sd} \times z \quad \ldots\ldots (4)$$

$$\text{Sd} = \sqrt{\frac{\Sigma(x - x')^2}{n}} \quad \ldots\ldots (5)$$

Information:

Sdl = Safety Stock
Z = safety factor
Sd = Standard Deviation of Demand

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3. Reorder Point

Determining the reorder point must pay attention to things such as the use of materials during the period before the order came, the amount of safety stock. Because it relates to how much inventory remains in the warehouse, a new order is made. The reorder point formulation is as follows:

$$ROP = (d \times L) + SS \quad \ldots\ldots (6)$$

Information:

ROP = Reorder Point (reorder point)
L = Lead time or waiting time
D = level of demand per unit of time
SS = Safety stock or safety stock

4. JIT method

Calculations using the JIT method focus on near-zero inventories where materials arrive where they are needed and only when they are needed. This can minimize inventory costs incurred by the company. Calculations with the JIT method include:

a) Optimal Shipping Amount

$$na = \left(\frac{Q}{2 \times a}\right)^2 \quad \ldots\ldots (7)$$

Information:

Na = Optimal number of shipments
Q = Quantity used raw materials
a = Average target specific inventory in units

b) Order Quantity for One Order

$$Qn = \sqrt{na} \times Q * \quad \ldots\ldots (8)$$

Information:

Qn = Order quantity
na = Optimal number of shipments
Q* = EOQ

c) Total Minimum Annual Inventory Cost

$$T^* = \frac{C \times Q^*}{2} + \frac{O \times D}{Q^*} \quad \ldots\ldots (9)$$

Information:

T* = Total inventory cost
O = Ordering cost
D = Total use of raw materials
C = Storage fee

d) Optimal Shipping Quantity

$$q = \frac{Qn}{na} \quad \ldots\ldots (10)$$

Information:

Q = Optimal shipping quantity
Qn = Order quantity
Na = Optimal number of shipments

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e) Order Frequency JIT

$$n = \frac{D}{Qn} \quad \text{.....(11)}$$

Information:
n = Purchase frequency
D = Total use of raw materials
Qn = Order quantity

f) Total Minimum JIT Inventory Cost

$$T_{jit} = \frac{1}{\sqrt{n}}(T*) \quad \text{..... (12)}$$

Information:
Tjit = Total Inventory Cost
n = Purchase frequency
T* = Total inventory

5. Comparative Analysis of Each Method:

After processing the data and conducting the inventory control analysis using the EOQ and JIT methods, a comparative analysis can be performed to determine the effectiveness of each method. The calculation results, particularly the Total Inventory Cost (TIC), obtained from both methods will be compared with the data collected before the research was conducted. This comparison will help assess whether the results align with the problem formulation and study objectives. By comparing the TIC values obtained from the EOQ and JIT methods, it will be possible to determine which method provides the most optimal results in inventory control. The method with the lower TIC indicates a more efficient and cost-effective inventory management approach.

6. Study Results and Proposed Inventory Methods: Based on the analysis conducted, the study will yield results regarding the most efficient and profitable calculation of inventory costs for the company. These results will demonstrate the ability to control inventory at an ideal level.Furthermore, based on the findings, the study will propose the most suitable inventory control method for the company. This recommendation will take into account factors such as the TIC, inventory levels, order frequencies, and other relevant considerations. The proposed method will aim to optimize inventory management, reduce costs, and ensure a smooth flow of materials throughout the company's operations.

3. RESULT

3.1 Company Actual Data Processing Results

Based on the company's actual data processing results for inventory control in 2022, the following information has been obtained:

1. The cost of ordering sample cans for each order is IDR 270,000.

2. The company incurs a storage fee of IDR 5,460.4 per unit per year.

3. The quantity of sample cans purchased by the company is 1,120 units for 4-liter cans and 1,300 units for 1-liter cans.

4. The frequency of purchases made by the company is 4 times in one year.

5. The total cost of inventory incurred by the company amounts to IDR 5,222,849.163 in one year.

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These data reflect the current inventory control practices of the company, including the costs associated with ordering and storing sample cans. It provides a baseline for comparing the results obtained through the EOQ and JIT methods, enabling an assessment of the effectiveness and efficiency of the company's inventory management.

3.2 Results of Data Processing EOQ Method

Based on the data processing using the EOQ method and historical company data from 2022, the following results have been obtained:

1. The economical order quantity for sample cans is calculated as 329.37 for 4-liter cans and 351.32 for 1-liter cans.
2. The optimal order frequency for the company is determined as 3.33 times for 4-liter cans and 3.55 times for 1-liter cans per year.
3. By implementing the EOQ method with the calculated order quantities and optimal order frequency, the total cost of inventory incurred by the company amounts to IDR 1,798,508.2 for 4-liter cans and IDR 1,918,299.45 for 1-liter cans, resulting in a total of IDR 3,716,814.582 in one year.
4. The safety stock or minimum inventory level that the company should maintain for smooth operations is 23 pieces for 4-liter cans and 33 pieces for 1-liter cans.
5. The reorder point, indicating when sample cans need to be reordered to avoid stock shortages, is determined as 32.03 pieces for 4-liter cans and 43.26 pieces for 1-liter cans.

The calculations using the EOQ method reveal significant differences compared to the company's current practices, where purchases are made in uncertain quantities and at uncertain times depending on the availability of stock in the warehouse. By adopting the EOQ method and purchasing with the determined economical order quantities, the ordering costs will be equivalent to the holding costs (Nababan, 2017). The frequency of purchases based on the EOQ method also differs slightly from the company's current frequency of 4 times. These results highlight the potential benefits of implementing the EOQ method, such as reducing inventory costs and maintaining optimal inventory levels. The findings suggest that the company could improve its inventory control by adopting the EOQ method and aligning its ordering practices with the calculated quantities and frequencies.

3.3 JIT Method Data Processing Results

Based on the data processing using the JIT method and historical company data from 2022, the following results have been obtained:

1. The optimal number of cans to be sent is determined as 2,447 times for 4-liter cans and 2,338 times for 1-liter cans.
2. For each order, the optimal order quantity is calculated as 515.23 pieces for 4-liter cans and 537.19 pieces for 1-liter cans.
3. By implementing the JIT purchasing scheme, the company's total annual inventory cost amounts to IDR 1,798,508.2 for 4-liter cans and IDR 1,918,299.45 for 1-liter cans.
4. The optimal shipping quantity in one shipment is determined as 210.56 pieces for 4-liter cans and 229.77 pieces for 1-liter cans.
5. The most optimal purchase frequency for the company is 2.31 times for 4-liter cans and 2.32 times for 1-liter cans.

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6. The total minimum inventory cost that the company would incur when applying the JIT method is IDR 1,149,728.87 for 4-liter cans and IDR 1,254,508.97 for 1-liter cans, resulting in a total of IDR 2,404,237.84.

Based on these calculations using the JIT method, the recommended order frequency and order quantities differ from the company's current practices. To implement the JIT method effectively, the company would need to establish contracts with suppliers, both long-term and short-term, to ensure the availability of larger quantities of goods with more frequent deliveries, as agreed upon in the contracts. This approach aims to streamline inventory management, reduce costs, and maintain optimal inventory levels throughout the year.

3.4 Comparison Between Company Actual Calculation, EOQ Method, and JIT Method

The current inventory control system at PT Geoservices Inspection Services Division for sample cans is still manual. Orders are placed based on the remaining balance at the beginning of the year and when the stock level is perceived to be low. However, the absence of a regular system or schedule for purchasing sample cans presents several challenges. The fluctuating usage of sample cans makes it difficult to predict when there will be increased demand without sufficient supply to meet those needs. This irregularity in purchasing can lead to inconsistent frequencies of orders, resulting in higher total costs for the company. Moreover, stock shortages can disrupt inspection service provision activities and lead to financial losses. After processing the data and calculating the Total Inventory Cost using the EOQ, JIT, and the company's current methods, the results are presented in Table 1.

Table 1. Comparison Between Company Actual Calculation, EOQ Method, and JIT Approach

	Company Method		EOQ Method		Just In Time Method	
	4 Liter Cans	1 Linter Cans	4 Liter Cans	1 Linter Cans	4 Liter Cans	1 Linter Cans
Raw Material Needs per Year	1097	1248	1097	1248	1097	1248
Optimal Order Quantity	280	325	329,37	351,32	515,23	537,19
Order Frequency per Year	4x	4x	3,33x	3,55x	2,31x	2,32x
Delivery frequency per Order	1x	1x	1x	1x	2,447x	2,338x
Total Inventory Cost			Rp 1.798.508,2	Rp 1.918.299,45	Rp 1.149.728,87	Rp 1.254.508,97
Total	**Rp 5.222.849,163**		**Rp 3.716.814,582**		**Rp 2.404.237,84**	

Based on the comparison results in Table 1, it is evident that the actual quantity needs for 4-liter cans and 1-liter cans are 1097 and 1248, respectively. Comparing the optimal order quantities, the actual conditions of the company result in 280 pieces for 4-liter cans and 325 pieces for 1-liter cans, obtained from the average material purchases. However, using the EOQ method, the quantities for 4-liter cans and 1-liter cans are 329.37 and 351.32, respectively. On the other hand, the JIT method yields quantities of 515.23 for 4-liter cans and 537.19 for 1-liter cans. Regarding the order frequency, the company's actual method is 4 times a year for both types of cans. However, with the EOQ method, the frequencies for 4-liter cans and 1-liter cans are 3.33 and 3.55 times, respectively, while the JIT method suggests frequencies of 2.31 and 2.32 times for 4-liter cans and 1-liter cans, respectively. The delivery frequency per order for the company's actual method and the EOQ method is 1 time, while the JIT method involves 2,447 and 2,338 shipments for 4-liter cans and 1-liter cans, respectively. Considering the total inventory cost in a year, the company's

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actual method incurs IDR 5,222,849.163, while the EOQ method results in IDR 3,716,814.582, and the JIT method leads to IDR 2,404,237.84. Based on the total inventory costs, it can be concluded that the JIT method is the most optimal inventory control method for Inspection Services Division. When sorted from largest to smallest total costs, the company's actual method has the highest cost, followed by the EOQ method, and the JIT method has the lowest total cost. These findings suggest that the company's manual inventory control is not optimal. By implementing the JIT method with order quantities of 515.23 for 4-liter cans and 537.19 for 1-liter cans, order frequencies of 2.31 and 2.32 times, and delivery frequencies of 2,447 and 2,338 times, the company can save a total inventory cost of IDR 2,818,611.323.

The results of this study demonstrate that implementing inventory control using the EOQ and JIT methods at Inspection Services Division can lead to reduced total inventory costs, with the JIT method resulting in the highest cost savings. These findings align with previous research by (28;30) on the comparative analysis of methanol raw material inventory control using the EOQ and JIT systems, which found that both methods can function effectively and efficiently in companies. The JIT system was considered more efficient, delivering greater cost savings and overall inventory cost efficiency compared to the company's existing method.

4. CONCLUSION

Based on the research conducted using the EOQ and JIT methods, the following conclusions can be drawn:

1. Total Inventory Cost: The total cost of inventory incurred by the company in one year is IDR 3,716,814.582 using the EOQ method and IDR 2,404,237.84 using the JIT method. This indicates that the JIT method results in lower inventory costs compared to the EOQ method.

2. Optimal Order Quantity and Frequency: The EOQ method suggests an optimal and economical order quantity of 329.37 pieces for 4-liter cans and 351.32 pieces for 1-liter cans. The JIT method recommends order quantities of 515.23 pieces for 4-liter cans and 537.19 pieces for 1-liter cans. The order frequency for the EOQ method is 3.33 times for 4-liter cans and 3.55 times for 1-liter cans, while the JIT method suggests frequencies of 2.31 times for 4-liter cans and 2.32 times for 1-liter cans. These findings highlight the specific quantities and frequencies that would lead to more efficient inventory management.

3. Shipment Frequency: With the EOQ method, shipments are made once for both types of cans. In contrast, the JIT method requires shipments of 2,447 times for 4-liter cans and 2,338 times for 1-liter cans. This indicates that the JIT method involves more frequent and smaller shipments to maintain optimal inventory levels.

4. Optimal Method: After comparing the EOQ and JIT methods with the company's actual conditions, it is evident that the JIT method is the most efficient and profitable approach. By implementing the JIT method, the company can save a total inventory cost of IDR 2,818,611.323. The JIT method ensures that inventory is held only when materials are needed, resulting in cost savings and improved efficiency.

These conclusions demonstrate the advantages of implementing the JIT method over the EOQ method and the company's actual inventory control practices. The JIT method allows for more precise inventory management, reducing costs and optimizing operational efficiency.

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