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Planning of Consumable Packing Warehouse To Solve Packing Delays Using Probabilistic Economic Order Quantity (EOQ) Methods

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Abstract: The problem in this study is that opened a new fulfillment warehouse and there was a shortage of stock items for warehouse process activities. The shortage occurs in consumable items such as bubble wrap and duct tape in the packing activity of one of the items, namely children's books. This study aims to determine the optimal amount of inventory order, the frequency of orders, and the optimal total cost of inventory. In this study using the Economic Order Quantity (EOQ) model with backorder considers running out of inventory that has been calculated. The results showed that the optimal amount of time bubble wrap and transparent adhesive tape in sequence was 101 Roll dan 156 Roll with order point each bubble wrap and transparent adhesive tape 7 Roll dan 8 Roll, and for the total cost of optimal Bubble Wrap and transparent adhesive tape inventory in sequence of IDR 1.206.472 dan IDR 409.044.
Keywords: *Inventory, Consumable Packing, EOQ Probabilistic, Warehouse, Fulfillment*

1. Introduction

Currently, the Indonesian economy is very much colored by online trading commonly known as e-commerce. This is our hope for economic equality to improve the economy in Indonesia (Akbar et al., 2021). Inventory management must be organized to reduce inefficiencies in the flow of operational activities to be functional and facilitate smooth operations (Puspita et al., 2021).

Fulfillment Warehouse service is a process or activity in the warehouse in the form of order fulfillment starting from procuring materials from suppliers until the goods reach the end consumer (Akbar et al., 2021; Chamsudi et al., 2022; Maulana, Pratiwi, et al., 2022). In warehouse operations, order processing is focused on fast selection and accurate delivery to maximize customer satisfaction so that warehouse work is hampered (Maulana, Wiguna, et al., 2022). In the fulfillment warehouse, logistics technology companies provide services in the form of warehouse rentals. One of these warehouses is the Business to Customer (B2C) Fulfilment Warehouse, which is used to accommodate goods from consumer goods manufacturers and prepare goods requested by consumers. However, in the process, there is a delay in the outbound process, namely the packing process.

The problem occurred due to the lack of a strategy for procuring consumable goods that would be used in the warehouse for the activities of the process of packing goods in books so there were operational delays. Examples of consumable items are packaging cardboard, bubble wrap, transparent adhesive tape, thermal 100x100, and so on. The occurrence of these problems is because the company does not have a strategy or method related to inventory control so if it occurs continuously in ordering it results in losses to the company (Widina & Muchammad Fauzi, 2024). According to (Parlindungan et al., 2022), the method used in the case is Economic Order Quantity (EOQ) which has the same case and has a solution or goal in seeking to control the inventory of the main raw materials.

This research aims to seek control of the main raw material inventory where it is necessary to optimize the amount of raw material inventory in addition to that. This method can also calculate the amount in the form of the maximum amount of inventory that must be provided in the initial ordering cycle which is expected to minimize the total inventory cost and can meet consumer demand without harming the company itself.

2. Literature Review

In logistics operations, the efficiency of consumable packing warehouses plays a pivotal role in ensuring the smooth flow of goods and preventing bottlenecks. Packing delays within such environments can disrupt the supply chain, leading to increased costs, lowered customer satisfaction, and compromised operational performance. To address this issue, diverse methodologies have been explored, with the Economic Order Quantity (EOQ) model emerging as a prominent approach. While traditional EOQ methods focus on deterministic demand patterns, the probabilistic EOQ model accommodates uncertainties in demand, providing a more flexible and adaptive framework for warehouse planning.

The EOQ model, introduced by Ford Harris in the early 20th century, has undergone significant evolution to suit complex and dynamic logistics systems. Classical EOQ formulations operate under assumptions of stable demand and consistent lead times. These premises often fall short in real-world applications, particularly in consumable packing environments where demand is volatile and subject to fluctuations. Probabilistic EOQ addresses this gap by incorporating stochastic elements, enabling decision-makers to optimize inventory levels in the face of variability.

Numerous studies highlight the efficacy of probabilistic EOQ in mitigating packing delays. (Chopra & Meindl, 2019) emphasize its relevance in scenarios where unpredictable demand patterns arise, noting that the integration of probabilistic demand forecasting within EOQ calculations can significantly reduce stockouts and enhance packing efficiency. Similarly, (Silver et al., 2016) argue that probabilistic EOQ enables warehouses to balance holding costs with service-level requirements, ensuring a responsive system that adapts to market dynamics.

Another critical aspect explored in literature is the role of warehouse layout and design in amplifying the benefits of EOQ models. Richards (2017) underscores the importance of aligning inventory management practices with spatial planning, illustrating that warehouses equipped with adaptive storage configurations can better accommodate variability in packing operations. This integration ensures that probabilistic EOQ calculations are complemented by physical infrastructure capable of responding to fluctuating demand.

3. Research Method

The method used in this research is quantitative methods with the probabilistic Economic Order Quantity (EOQ) as an analysis tool. The results of data collection are processed using Microsoft Excel for warehouse consumable needs in the past year. After the data is processed using Microsoft Excel, the researcher conducts a normalization test using the software Minitab to determine whether the data is normally or abnormally distributed and can determine whether the data is a deterministic or probabilistic part with the Kolmogorov- Smirnov method shows a p-value greater than 0.05, then the data is normally distributed and vice versa, if the p-value is smaller than 0.05, then the data is not normally distributed.

In the optimal total order with the Probabilistic EOQ method, namely calculating the value of each parameter such as storage costs, ordering costs, reorder points, and safety stock. According to (Siswanto, 2007), the steps to calculate Probabilistic EOQ are as follows:

a) Safety Stock

To calculate the value of safety stock, the value of standard deviation and Z factor is required. The formula to determine safety stock is:

$$Safety\ stock = SD\ x\ Z \tag{1}$$

SD = Standard Deviasi
Z = Safety Factor Value (service level)

b) Reorder Point

$$ROP = D\ x\ L + SS \tag{2}$$

ROP = Re-Order Point
SS = Safety Stock
L = Lead Time
D = Demand

c) Inventory Cost

In calculating the total inventory cost, according to Siswanto (2007), the probabilistic value of Q must first be determined, which will provide the smallest value of total inventory cost, using the following equation:

$$\sqrt{\frac{2D(S + BK\sum(Ki - SP)P(Ki))}{h}} \tag{3}$$

Once the probabilistic Q is determined, the following is the mathematical model for the total inventory cost:

$$Inventory\ cost\ (BTP) = \frac{D}{Q}S + \frac{Q}{2}h + BS + BKP + BP \tag{4}$$

D	= Demand
h	= Storage Cost
S	= Ordering Cost
Q	= Optimal order quantity
BKP	= Cost of Out of Stock
Ki	= Expected usage during lead time
RP	= Reorder point
P(ki)	= Probability of usage during lead
BS	= Storage cost x Safety Stock
BP	= Purchase Cost

4. Results and discussion

Consumable Goods Data

The Fulfillment Warehouse has a shortage of two consumable raw materials, namely transparent adhesive tape and Bubble with a sample of one of the Warehouse management customers with items in the form of children's books with backorders occurring 70 Roll Bubble Wrap and 64 Roll transparent adhesive tape. The book sample has a size of 17.5cm x 17.5cm x 1.5cm for one book with a need for 60cm x 30cm Bubble Wrap and 55cm Long transparent adhesive tape.

Table 1

Consumable goods data

	Bubble Wrap	Transparent Adhesive Tape
Lead Time	2 Days	2 Days
Order Cost	Rp 100.000	Rp 30.000
Purchase Cost	Rp 30.000	Rp 5.000
Storage Cost = Price x 2	Rp 7.800	Rp 1.300
Cost of Out of Stock	Rp 100.000	Rp 100.000
Working Day	276 Days	276 Days

Data Processing

The data on stock shortages that occurred throughout the year 2023 is used to determine how often stock shortages occurred during that period. Below is the data obtained by the researcher:

Table 2

Backorder in 2023

Month	Actual (roll)		Backorder (roll)	
	Bubble wrap	Tape	Bubble wrap	Tape
January	50	80	5	3
February	50	80	3	1
March	50	80	3	1
April	50	80	4	2
May	50	80	7	7
June	50	80	5	5
July	50	80	9	9
August	50	80	8	9
September	50	80	8	8
October	50	80	6	6
November	50	80	5	4
December	50	80	8	8
TOTAL	**600**	**960**	**70**	**64**

The data processing of consumable goods needs in the research is conducted to determine the consumable goods required for customer orders over the course of one year, calculated every month from January to December. The calculation results are as follows:

Table 3

Demand of bubble wrap and transparent adhesive tape

Month	Bubble Wrap (roll)	Transparent Adhesive Tape (roll)
January	55	83
February	53	81
March	53	81
April	54	82
May	57	87
June	55	85
July	59	89
August	58	89
September	58	88
October	56	86
November	55	84
December	58	88
TOTAL	**670**	**1.024**

Based on the results of the data normality test using Minitab software, it is known that the data is a normal distribution. Calculations using Kolmogorov Smirnov for a sample size of 12 months of consumable goods needs with Alpha (α) Bubble Wrap P Value 0,150 and Transparent Adhesive tape 0,150 greater than 0,05, so the data is normally distributed. This simulation is carried out using Minitab software, it can be seen that the data obtained fluctuates or is different. The graph also proves that the data is probabilistic because the data pattern is known and also proven in the normality test that S ≠ 0.

Figure 2

Data Pattern Graph

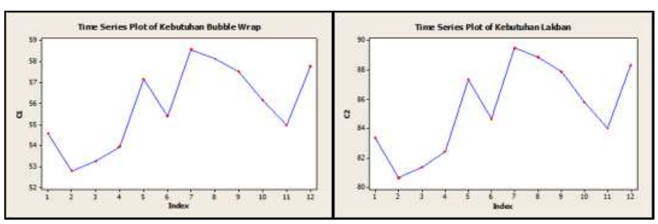

Fig. 1. Pattern of the data

EOQ Probabilistic

a) Bubble Wrap

Safety Stock (SS)

The service level is 90%. The Z value uses the NORMSINV formula and produces a safety factor value of 1.282 so that it can then calculate the Standard Deviation value. The safety stock (SS) is 2 rolls (2x1,282).

Reorder Point

In the process of ordering consumables, Bubble Wrap and transparent tape each require a lead time of 2 days for each order. The use of consumable items needed for the next 12 periods is 670 rolls of Bubble Wrap and 1024 for tape, in 1 year there are 276 working days. Thus, the reorder point value for the next period is obtained as 7 rolls for bubble wrap. After determining the ROP for the consumable item.

Table 4

Bubble wrap usage during lead time

Month	Needs (roll)	Working day (day)	Consumable usage (roll)	Lead time (day)	Usage during lead time (roll)
January	55	23	2,37	2	4,745
February	53	23	2,29	2	4,589
March	53	23	2,32	2	4,631
April	54	23	2,35	2	4,690
May	57	23	2,49	2	4,970
June	55	23	2,41	2	4,818
July	59	23	2,55	2	5,093
August	58	23	2,53	2	5,057
September	58	23	2,50	2	5,002
October	56	23	2,44	2	4,883
November	55	23	2,39	2	4,780
December	58	23	2,51	2	5,025
TOTAL					**58,285**

It was found that the total rice usage during the lead time for the next 12 periods was 58,285 rolls. With the expected usage of 5 rolls of average usage in the next 1 year. For the next 12 periods are 4,857 rolls bubble wrap and in the interval 4,793 - 4,894 which means the probability of usage during the lead time is 0,167.

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Optimal Q dan Total Cost of Inventory

$$Q = \sqrt{\frac{2D(S+BK\sum(Ki-SP)P(Ki))}{h}}$$

$$= \sqrt{\frac{2\ x\ 670(100.000+100.000\sum(4{,}857-7)\ x\ 0{,}167)}{7.800}}$$

Qopt = 101 Rolls Bubble Wrap

Inventory cost

$$BTP = \frac{D}{Q}S + \frac{Q}{2}h + BS + BKP + BB$$

$$= \frac{670}{101}\ x\ 100.000 + \frac{670}{2}x\ 7.800 + 19.044 + 100.000 + 30.000$$

Total Inventory Cost = Rp 1.206.472

b) Transparent Adhesive Tape

Safety Stock (SS)

The service level is 94%. The Z value uses the NORMSINV formula and produces a safety factor value of 1.555 so that it can then calculate the Standard Deviation value. The safety stock (SS) is 5 rolls (3x1.555).

Reorder Point

The reorder point value for the next period is obtained as 8 rolls for bubble wrap. After determining the ROP for the consumable item. It was found that the total use of rice during the lead time for the next 12 periods amounted to 89,046 Rolls. With the expected usage of 8 Rolls average usage in the next 1 year.

Table 5

Transparent Adhesive during lead time

Month	Needs (roll)	Working day (day)	Consumable usage (roll)	Lead time (day)	Usage during lead time (roll)
January	83	23	4	2	7,249

February	81	23	4	2	7,011
March	81	23	4	2	7,075
April	82	23	4	2	7,166
May	87	23	4	2	7,593
June	85	23	4	2	7,360
July	89	23	4	2	7,781
August	89	23	4	2	7,726
September	88	23	4	2	7,643
October	86	23	4	2	7,461
November	84	23	4	2	7,303
December	88	23	4	2	7,678
TOTAL					**89,046**

Optimal Q dan Total Cost of Inventory

$$Q = \sqrt{\frac{2D(S+BK\sum(Ki-SP)P(Ki))}{h}}$$

$$= \sqrt{\frac{2 \ x \ 1024(30.000+100.000\sum(7{,}420-8) \ x \ 0{,}250)}{1.300}}$$

Qopt = 156 Roll tape

Inventory cost

$$BTP = \frac{D}{Q}S + \frac{Q}{2}h + BS + BKP + BB$$

$$= \frac{1024}{156} \ x \ 30.000 + \frac{1024}{2} x \ 1.300 + 5.882 + 100.000 + 5.000$$

Total Inventory Cost = Rp 409.044

5. Conclusion

With the problem of lack of stock of consumable packing supplies with Probabilistic EOQ calculations resulting in optimal ordering in messages of 101 Rolls for Bubble Wrap and 156 Rolls for tape in one message and Safety Stock on Bubble Wrap as much as 2 Roll while on duct tape as much as 5 Roll for safety stock. The reorder point on Bubble Wrap reorders when the bubble wrap reaches 7 Rolls while the duct tape reorders when the bubble wrap reaches 8 Rolls with the total cost of inventory on each consumable is very large and significant, namely the BTP required Rp 1.206.472 for Bubble Wrap inventory costs and Rp 409.044 for the total cost of tape inventory.

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