The Design of Product Inventory Strategy with System Thinking and Economic Order Quantity Method Approach (Case Study: PT. Y)

R D Lufika
Jl. Syekh Abdurauf As Sinkili No.7, Kopelma Darussalam, Kec. Syiah Kuala, Banda Aceh City, Aceh, Indonesia. Post Code: 23111
raihandlufika@gmail.com

Abstract. The global supply chain allows companies to distribute their product all around the globe. The companies have to prepare themselves with an integrated system that is involving the possibility to deliver the product to the farthest area within their regional target. However, the limited due date of products generates the distribution and inventory problem that is complex and challenging to solve. One of the methods to solve the distribution problem of products with the due date is to use the system thinking approach to identify the root of the problem. The Economic Order Quantity (EOQ) method is the most reliable method to discover the most cost-effective strategy, especially for products with the limited due date. The company for this case study is PT Y. The main problem of the company is stock out. The result shows the root of the problem in this company is the unstable demand from the customer, storage management, and distribution management. There are similarities between the three root problems. The due date and quantity are the factors that control the three root problems. The result also shows that the EOQ Model that is taking the due date into account is more expensive than regular EOQ model. Keywords: Distribution, EOQ Model, Distribution, Inventory, Stock Out, System Thinking

1. Introduction

Indonesia is an archipelago country surrounded by sea. Therefore, the food and logistics distribution is one of the main challenges in Indonesia because most of the transportation chain requires more than one type. Most of the factory is located in Java Island. Then the product will be distributed to other regions via air, water, or road transport. The company needs to decide the production quantity for each manufacturing process.

The various variables in the problem influence the complexity of deciding on the distribution process. The problem consists of several small individual problems which actually have the same root. The system thinking is the system itself [1]. It is significant to view the small problem as a part of the whole system because of the problems, in fact, are related to each other.
The factory is not the only parties that experience the problem with the distribution system. The company branch also has a distribution problem. The company branch usually receives a certain amount of product, store it for some time, and sell it to the customer. Most of the time, the decision of inventory and order quantity refers to the forecast result. However, the forecast result is not always reliable. Therefore, another approach is necessary to support this decision. The Economic Order Quantity (EOQ) method will support the forecast result from the cost perspective. For the continuous and discrete-time model, the requirement of cautiously transferring the results to analysis framework is necessary [2].

2. Literature Review

2.1. Warehouse Inventory

A warehouse is a necessary ‘evil’ in the manufacturing industry because of its high cost and time-wasting activity. However, the warehouse has an important role in the company. The warehouse has several functions such as receive the products, inspection and quality control, repackaging, put away, storing, order picking, postpone, sorting, packing and shipping, cross-dock, and replenishment [3].

2.2. Distribution

Distribution management is one of the difficult problems in supply chain and logistics system. The distribution usually involves the third-parties as to a partner for distribution. Therefore, the decision in distribution management has to rely on third-party policies. In the integrated supply chain system, the scheduling is rely on the schedule of production, order acceptance, batches allocation and delivery [4].

2.3. System Thinking

The system thinking is a new way of thinking that refers to the problem as part of the whole system [5]. In this method, instead of solving each problem separately, it is more efficient to solve the problem as the whole system. The system thinking is useful for many different cases such as a flood disaster management [6] and . There are several tools to understand the problem situation which are mind maps, rich pictures diagram, and cognitive maps [5]. While the tools help the researcher to present the idea in an easy way to make reader understand, it is important for the researcher itself to understand it first. There are four approaches to design the system thinking tools which are perception, product, practice, and strategies [7]. The system thinking allows the researcher to understand other people perspective [8].

2.4. Economic Order Quantity (EOQ) Model

The EOQ model can support the core decision in inventory which are when and how much to order [9]. The EOQ results can support the order quantity decision to support the forecast result. The situation in each company differs with another. The modification of EOQ will always start from the basic EOQ. One of the examples is the modification of EOQ with a fixed lifetime [10] and the perishable product [11]. Different policy applies different cost function. There is a high holding cost in the perishable model [12].

3. Methods
3.1. Methods

The research method shows in Fig 3. The case study is conducted at PT Y. PT Y is the distributor of beverage product located in Banda Aceh. The company distributing the product to ten different districts in Aceh which are Banda Aceh, Aceh Besar, South Aceh, Bireuen, West Aceh, Pidie, Blang Pidie, Pidie Jaya, Nagan Raya, and Aceh Jaya. The most significant problem that regularly occurs in PT Y is stock out. Stock out is the situation when the products are not available as much as the demand from the customer. This situation is harming the company because the stock out cost is relatively large. When the stock out situation occurs in PT Y, the company was asking to increase their order quantity to the main factory in Cilegon, West Java. This strategy is significant in solving the problem of stock out at the moment. However, along with the improvement, the company has a new problem, the storage management and delivery capacity. The due date of the product is relatively short. The due date is 40 days after the final production process. Calculating the delivery period into the warehouse which is around five to six days, the company has 35 days left to sell the products. Therefore, the company has to think and calculate carefully before ordering the extra quantity in order to minimise the loss and managing the storage and delivery. The company has a demand of 1,440,000 bottles per month. The ordering cost is 300,000 IDR per order. The holding cost is 10% of purchasing cost which is 1,540 IDR per bottle. The over due date cost is 50% of selling cost which is 1,620 IDR.

3.2. System Thinking Approach

One of the basic approaches of system thinking is mind map. The goal of using a mind map as the basic approach is to identify the whole problem with the details explanation of the causes and effects of the problem itself. After the interview and brainstorming with the manager of the PT Y, there are three main roots for the situation of stock out situation in the company. The mind map of the problem in details is defined as Fig 4 below.

The picture shows that there are three problems which are causing the stock out situation. The problems are unstable demand, storage management, and distribution management. The unstable demand is linking to the demand from new stores and cafes in the ten districts especially in Banda Aceh. The other thing is the demand of individuals and catering. It is high risk to stocking the product with a short due date than one with the long due date. While the company can estimate the demand from stores and cafes based on the numbers of the loyal customers, it is almost impossible to estimate the demand from individuals and catering whom directly buy the product from the company. Therefore, on top of forecasting the demand, the company has to calculate the extra stock to meet the demand from individuals and catering.

The storage management is linking with the decision of ordering quantity to the factory. The company is ordering the products fortnightly. The amount is varied between 180,000–250,000. The company’s storage itself has a capacity of 270,000 bottles. The problem with storage management is the requirement of keeping the temperature below 10°C regarding the number of bottles. The delivery policy is First In First Out (FIFO). The ordering capacity is rely on the expedition company which
should match the quantity with other branches along the route as well, such as Medan and Lhokseumawe.

![Stock Out Mind Map](image)

**Figure 2. Stock Out Mind Map**

The distribution management is linking with the capacity of the delivery cars. There are two types of car in the company. There are eight units of L300 cars (Type A) with the capacity of 18,000 bottles and there are five units of FE71 Canter (Type B) with the capacity of 35,000 bottles. The problem is to assign which car will cover which district. The company usually assign the type A car to distributing products to Banda Aceh, Aceh Besar, West Aceh, and Pidie. The type B car covers the remains districts. It is important to have an immediate decision for the distribution because the longer cars depart, the shorter the product due date remains. The car assign decision is based only on the data and habit from the past.

3.3. **EOQ Model**

3.3.1. **Basic EOQ Model**

The basic EOQ Model assumes that the demand is deterministic and constant [13]. The other assumption is as follow. The ordering cost occurs immediately after the quantity order is placed. Then, there is zero lead time and no shortage allowed. The calculation of basic EOQ refers to the formulation by Winston [14] as follow.

$$ q^* = \left( \frac{2KD}{h} \right)^{\frac{1}{2}} \quad (1) $$

Where:

$q^*$ = Order Quantity, $K$ = Ordering Cost, $D$ = Demand, $h$ = Holding Cost

| Table 1. Basic EOQ Results |
|-----------------------------|
| Order Quantity | 74,903 Units |
| Order Frequency | 20 Times |
| Total Cost | 2,229,134,990 IDR |
3.3.2. EOQ Model with Due Date Consideration

The assumption for the EOQ model defines as follow. Firstly, demand is deterministic and constant. Second, the ordering cost occurs immediately after the quantity order is placed. Third, there is zero lead time. Fourth, no shortage allowed. Fifth, the products which over the due date is disposed immediately and the cost of disposing of the product occurs. The calculation of EOQ with due date consideration refers to the formulation by Rikardo [15] with modification as follow.

\[
Q = \left(\frac{4KD - phQ_{dd}^2 + 4SDQ_{dd}}{ph}\right)^{\frac{1}{2}}
\]  

(2)

Where:
- \(Q\) = Order Quantity,
- \(K\) = Ordering Cost,
- \(D\) = Demand,
- \(p\) = Purchasing Cost,
- \(h\) = Holding Cost,
- \(Q_{dd}\) = Quantity Over Due Date,
- \(S\) = Over Due Date Cost

| Table 2. EOQ with Due Date Consideration |
|-----------------------------------------|
| Order Quantity | 10,201 Units |
| Quantity Over Due Date | 9837 Units |
| Order Frequency | 20 Times |
| Total Cost | 3,427,121,429 IDR |

4. Results

Each root problem has a different cause and effects. There is a solution suggestion for each problem. The unstable demand comes from the increasing number of stores and cafes in the ten districts all over Aceh. The forecast demand and additional safety stock hopefully can solve the unstable demand from the customer both commercials and individuals.

Along with the high demand for the products, the company also increase the quantity order to the factory. Unfortunately, the factory will send the products at the same time to Medan and Lhokseumawe as well. Therefore, the number of bottles for each branch has to match the maximum delivery capacity of the third parties, the expedition company. The coordination with Medan and Lhokseumawe branches is the key solution for ordering the appropriate bottles.

The area of coverage is quite significant. The farthest district from the company is South Aceh with 335 km distance which is passing other regions. Therefore, the company usually assign the type B car with a higher capacity to the furthest city and several cities along the route. The judgement like West Aceh is relatively near to the company and the demand is still coverable by car type A, the distribution to this area has always used the car type A is not enough. It is important to use a method approach too.

While the EOQ results show that applying the EOQ model with due date consideration is more expensive than the basic EOQ. This is due to the extra cost of disposing of the over due date products. The basic EOQ order quantity is 74,903. The EOQ model with due date consideration order quantity is 10,201. This shows that the order frequency for the EOQ model with due date consideration is greater than the basic EOQ. This contributes to the total cost as well. However, considering the real situation on the company, the basic concept of EOQ is still reliable because, in fact, the expiration often occurs on the retailer/shop levels, not in the storage.

5. Conclusion

In conclusion, there are three root problems of the situation of stock out in PT Y. The problems are unstable demand from the customer, storage management, and distribution management. The EOQ
calculation results in the total cost of 2,229,134,990 IDR and the EOQ with due date results in the total cost of 3,427,121,429 IDR.

Acknowledgement

This research is supported by Universitas Syiah Kuala, Ministry of Research, Technology, and Education of Indonesia, in accordance with the Letter of Appointment Agreement of Laboratory Grant of Fiscal Year 2019 Number: 305/UN11.2/PP/PNBP/SP3/2019 Date February 8, 2019. Thanks and high appreciation to Rector, Head of Integrated Laboratory and Head of LPPM Universitas Syiah Kuala.

References

[1] R. D. Arnold and J. P. Wade, “A definition of systems thinking: A systems approach,” in *Procedia Computer Science*, 2015.
[2] A. G. Lagodimos, K. Skouri, I. T. Christou, and P. T. Chountalas, “The discrete-time EOQ model: Solution and implications,” *Eur. J. Oper. Res.*, 2018.
[3] J. A. Tompkins, J. A. White, Y. A. Bozer, and J. M. A. Tanchoco, *Facilities planning*. John Wiley & Sons, 2010.
[4] A. Noroozi, M. M. Mazdeh, M. Heydari, and M. Rasti-Barzoki, “Coordinating order acceptance and integrated production-distribution scheduling with batch delivery considering Third Party Logistics distribution,” *J. Manuf. Syst.*, vol. 46, pp. 29–45, Jan. 2018.
[5] H. Daellenbach, D. McNickle, and S. Dye, *Management science: decision-making through systems thinking*. Macmillan International Higher Education, 2012.
[6] J. Rehman, O. Sohaib, M. Asif, and B. Pradhan, “Applying systems thinking to flood disaster management for a sustainable development,” *Int. J. Disaster Risk Reduct.*, 2019.
[7] R. Buchanan, “Systems Thinking and Design Thinking: The Search for Principles in the World We Are Making,” *She Ji*, 2019.
[8] R. Jagustović, R. B. Zougmoré, A. Kessler, C. J. Ritsema, S. Keesstra, and M. Reynolds, “Contribution of systems thinking and complex adaptive system attributes to sustainable food production: Example from a climate-smart village,” *Agric. Syst.*, 2019.
[9] N. Thinakaran, J. Jayaprakas, and C. Elanchezhian, “Survey on Inventory Model of EOQ &amp; EPQ with Partial Backorder Problems,” *Mater. Today Proc.*, 2019.
[10] O. Enagbonma and I. B. Eraikhuemen, “Optimal ordering policies for the inventory system with fixed lifetime,” *Aust. J. Basic Appl. Sci.*, vol. 5, no. 12, pp. 3343–3348, 2011.
[11] C. Muriana, “An EOQ model for perishable products with fixed shelf life under stochastic demand conditions,” *Eur. J. Oper. Res.*, 2016.
[12] G. Dobson, E. J. Pinker, and O. Yildiz, “An EOQ model for perishable goods with age-dependent demand rate,” *Eur. J. Oper. Res.*, 2017.
[13] H. Liao and Q. Deng, “A carbon-constrained EOQ model with uncertain demand for remanufactured products,” *J. Clean. Prod.*, 2018.
[14] W. L. Winston and J. B. Goldberg, “Operations Research: Applications and Algorithms, Brooks/Cole—Thomson Learning,” *Inc., Belmont (CA)*, 2004.
[15] C. Rikardo, T. Limansyah, and D. Lesmono, “Model Persediaan Deterministik dengan Mempertimbangkan Masa Kadaluarsa dan Penurunan Harga Jual,” *Pros. Semnastek*, 2015.