Delivery Lot Size Optimization and Schedule of Shipment in Distribution Centre

I Rizkya1*, J Hidayati1, M M Tambunan1, J Utaminingrum1
1Departement of Industrial Enginnering, Faculty of Engineering, Universitas Sumatera Utara, Medan, Indonesia

*E-mail: indahrizkya@usu.ac.id

Abstract. This paper describes the optimal delivery lot sizes and plan delivery schedules from distribution center to manufacturer with a Distribution Requirement Planning (DRP). A company that produces nails has a problem that the planning and scheduling of goods distribution is not coordinated well. the demand for each product is out of control resulting in shortages or excesses as well as delays in distribution at each Distribution Center (DC). The purpose of this research is to analyze the distribution needs by using the Distribution Resources Planning (DRP) method to avoid delays in distributing products to each DC. Distribution analysis using the DRP method is used to get when and how many products will be sent for each DC. This method starts with calculating demand forecasting for the next 12 months. After obtaining the request results for the next 12 months, then the EOQ is calculated and the safety stock profit of each DC. With DRP method the optimal delivery quantity in DC Aceh 51.180 kgs, DC Padang 65.830 kgs, DC Pekanbaru 54.100 kgs, DC Palembang 67.225 kgs, and DC Medan 42.950 kgs. Using the optimal quantity delivery, frequency of shipment decreased until 51.5% and inventory cost decreased until 20.4%.

1. Introduction

The development of the business world has experienced intense competition and increased service for customers. The distribution system is one of the pillars that is important in the continuity and success of the company. Distribution is an effort to deliver products from the final production line to consumers with the goal on target, on time and at reasonable prices [1]. Distributors are required to deliver products well to prevent stock vacancies. Therefore, good management is needed to regulate the distribution system to work properly. A good distribution system performance can be seen from the availability of goods at each distribution center. Distribution is also a whole logistics process that involves sending the final product or service to the right place, at the right time and at the lowest cost [2].

DRP was suggested as an integrated approach to scheduling delivery and controlling inventory for a logistics system [3]. Distribution Requirement Planning is a distribution planning method to calculate product requirements at each distribution point. The DRP system is a complex information and control system, combining sales forecasting, inventory levels, and delivery problems, to schedule how much is needed, where and when [4,5]. DRP is able to resolve the problem of quantity, time, and location of delivery [6]. In multilevel distribution networks, distribution process can continue for various levels of warehouses such as the main warehouse, factory warehouse, distribution center, agent, etc [7,8]. The distribution process can be tiered at several levels of costumers ranging from distributors, wholesellers, retailers, to products to end users [9].
Several studies have been conducted on the application of DRP in several manufacturing industries. The first DRP implementation was carried out in the pharmaceutical industry to improve inventory turnover, improve service levels, and reduce distribution costs [10]. DRP method is widely used in some research before, one of which is the research conducted by Chrwan-jyh Ho (2007) concern to generalized system for delivery scheduling in a multi-sourcing logistics system [11]. A DRP system for increasing delivery flexibility and enhancing responsiveness to customer demand in the distribution network. This modified DRP is demonstrated to deal with an operating environment in which multi sourcing is a preferred distribution strategy. This system also allows a channel member to evaluate the performance of its suppliers using the criterion of on-time delivery. Finally, related research issues are discussed. The approach to DRP in the area of logistics. In addition, there are some of the following studies describing problem solving / solutions using the Distribution Resource Planning method. Distribution Resource Planning method with the addition of forecasting methods shows that the application of DRP can reduce distribution costs, make delivery scheduling to ensure delivery the right product, the right quantities, the right place, and the right time [4, 5].

Companies engaged in production of building materials have experienced several problems in the planning and scheduling of distribution. Products do not arrive at the distribution center on time. Because the company does not have good distribution planning and scheduling to anticipate the problems. Distribution Resource Planning (DRP) method is known to be able to schedule deliveries well so that inventory costs and delivery costs are minimum [6]. Many studies determine order lot size in the manufacturing industry, this time it is done at the distribution center.

2. Methodology
The study was carried out on one of the industrial factories in the city of Medan that produces building materials. The object examined in this study is the product distribution activity at the factory against each Distribution Center (DC), namely Aceh, Padang, Palembang, Pekanbaru, and Medan. The method used in this study is DRP. Distribution requirements planning (DRP) has been suggested as a scheduling method in the physical distribution system [1]. The data used in this study are data on the number of requests in 2017, lead time, project on hand (POH), inventory costs and delivery costs. The data that has been collected is then processed and analyzed with a predetermined procedure. DRP Calculation in 5 steps. There are:

a. Determine each DC demand forecast
At this initial stage, the demand data for each DC is predicted using the forecasting method.
b. Calculate the optimum delivery lot size.
   The optimum delivery quantity calculation is done using the Economic Order Quantity (EOQ) method which is used to determine the most economical delivery quantity. The purpose of EOQ to determine delivery quantity that will minimize the amount of inventory costs per period and delivery costs. EOQ calculation is done using the following formula [12]:

\[
EOQ = \sqrt{\frac{2xDxk}{h}}
\]  
(1)

Where D is the demand distribution center in time horizone planning, k is the delivery cost, and h is the inventory cost per period
c. Calculate the amount of safety stock for each DC
   In order for the stock status to remain safe, a safety supply for each distribution center (DC) must be made according to the average demand lead variance. Calculation of safety stock is done using the following formula [12]:

\[
Safety\ Stock = s x Z x \sqrt{L}
\]  
(2)

Where s is a standard deviation of requests at the distribution center, Z is the value under the normal curve which is determined by the level of service the company’s service level to the consumer is 95% and the Z value is 1.65. L is the lead time value.
d. Create DRP worksheets
After an optimal delivery quantity is obtained, the monthly product delivery plan determined using the DRP method. DRP worksheet [11] can be seen in Table 1.

| Table 1. DRP Worksheet |
|------------------------|
| On hand balance : | Lead time : |
| Safety stock : | Delivery Lot Size : |

| Past Due | Period |
|----------|--------|
| 1 | 2 | ……n |

- Demand
- In Transit
- Projected on Hand
- Net Requirement
- Planned Shipment - Receipt Date
- Planned Shipment - Ship Date

e. Create pegging information every DC
The source of information used to see how many requests for each DC at a certain time. This source of information is a list of requests that indicate where the request came from, both in terms of time and amount.

3. Result and Discussion

3.1. Demand Forecast in Every Distribution Centers
Forecasting is an important tool in effective and efficient planning [13]. To forecast the number of product requests for the next 12 months, it is done by looking at the historical demand in 2018. With ARIMA model (Autoregressive Integrated Moving Average) obtained the results of demand forecasting for each distribution center. The result of Demand forecasting for each distribution center 2019 can be seen in figure 1.

![Figure 1. Demand Forecasting Results for Each Distribution Center](image-url)
Based on the picture above, it can be seen that the demand for nail products has fluctuated every period. The number of requests for each DC product also varies. The highest average number of DC requests for each month is in DC Aceh. These results indicate that there is a fluctuating product demand for each period so that planning and scheduling of distribution activities is needed for each period to be fulfilled.

3.2. Optimization Delivery Lot Size
The optimum delivery quantity calculation for each distribution center is calculated using the Economic Order Quantity (EOQ) method. The delivery quantity calculation is also used to schedule distribution activities. Delivery quantity in this study uses the economic order quantity (EOQ) method that takes into account the distribution cost, holding cost, and product demand factors for each distribution center. Calculation of delivery quantity to each distribution center can be seen in Table 2.

| Distribution Center | Optimum Delivery Quantity (Kgs) |
|---------------------|---------------------------------|
| Aceh                | 51.180                          |
| Padang              | 65.830                          |
| Pekanbaru           | 54.100                          |
| Palembang           | 67.225                          |
| Medan               | 42.950                          |

Based on Table 2, the delivery quantity is quite high due to the high number of requests and delivery costs. By implementing delivery quantity based on EOQ calculations, it is expected that the company will not experience out of stock conditions due to uncertain shipments.

3.3. Calculation of safety stock
Safety stock is a stock that is reserved for the needs while waiting for the goods to arrive [8]. Safety stock in DRP is used to anticipate uncertainty of demand relative to the predictions made. The result of safety stock in DC Aceh, Padang, Pekanbaru, Palembang, and Medan namely 320 kgs, 645 kgs, 357 kgs, 870 kgs, and 256 kgs.

3.4. Distribution Requirement Planning
To make a product delivery schedule with DRP, it requires a bill of distribution. Bill of distribution has information about the distribution network chain and lead time delivery from the building material industry to the distribution center.

Planning of distribution schedule by DRP in weekly (52 weeks). Besides bill of distribution, it is needed the status on hand inventory and consumer demand prediction to perform DRP. Next step is calculating net requirements to know the product quantity needed to meet consumer at each distribution center. Net requirements are obtained by demand minus on hand inventory and in transit product plus safety stock. The Planned shipment receipt date is the time when product must be delivered in each DC to fulfil consumer demand. The planned shipment release date is the time when each DC must be ordered the product according to the optimal lot size that has been determined. Schedule of planned shipment release date is a pegging information.
3.5. Pegging information
Pegging Information is the source of information used to see how many requests for each DC at a certain time. This distribution scheduling is summarized in pegging information. Pegging information for each DC can be seen in table 3.

| Weeks | Pegging Information each Distribution Center |
|-------|---------------------------------------------|
|       | Distribution Center (kgs)                  |
|       | Aceh | Padang | Pekanbaru | Palembang | Medan  |
| 1     | 51.180 | 65.830 | 54.100 | 67.225 | 42.950 |
| 2     |       |       |         |         |       |
| 3     |       |       |         |         |       |
| 4     | 51.180 |       |         |         | 42.950 |
| 5     |       |       | 54.100 |         |       |
| 6     |       | 65.830 |         | 67.225 |       |
| 7     |       |       |         |         | 42.950 |
| 8     | 51.180 |       |         |         |       |
| 9     |       |       |         |         |       |
| 10    |       |       | 54.100 |         | 42.950 |
| 11    | 65.830 |       |         |         |       |
| 12    | 51.180 |       |         | 67.225 |       |
| 13    |       |       |         |         | 42.950 |
| 14    | 51.180 |       | 54.100 |         |       |
| 15    |       | 65.830 |         |         | 42.950 |
| 16    |       |       |         |         | 67.225 |
| 17    | 51.180 | 54.100 |         | 42.950 |       |
| 18    |       |       |         |         |       |
| 19    | 65.830 |       |         |         |       |
| 20    |       |       |         |         |       |
| 21    | 51.180 |       |         | 42.950 |       |
| 22    |       |       | 54.100 | 67.225 |       |
| 23    | 51.180 | 65.830 |         | 42.950 |       |
| 24    |       |       | 54.100 | 67.225 |       |
| 25    | 51.180 | 65.830 |         | 42.950 |       |
| 26    |       |       | 54.100 | 67.225 |       |
| 27    | 51.180 |       |         | 42.950 |       |
| 28    | 51.180 | 65.830 |         | 42.950 |       |
| 29    |       |       | 54.100 |         |       |
| 30    | 65.830 |       |         | 42.950 |       |
| 31    |       |       | 54.100 | 42.950 |       |
| 32    | 51.180 | 65.830 |         | 42.950 |       |
| 33    |       | 65.830 |         |       |       |
| 34    |       | 65.830 |         | 42.950 |       |
| 35    | 51.180 | 65.830 | 54.100 | 42.950 |       |
| 36    | 51.180 | 65.830 | 54.100 |       | 42.950 |
| 37    | 51.180 | 65.830 | 54.100 | 42.950 |       |
| 38    | 51.180 | 65.830 | 54.100 |       | 42.950 |
| 39    | 51.180 | 65.830 | 54.100 | 42.950 |       |
| 40    | 65.830 | 54.100 | 42.950 |       |       |
| 41    | 51.180 | 65.830 | 54.100 | 42.950 |       |
With the DRP worksheet and pegging information, the company will know when and how many products will be sent to each distribution center. Table 3 shows the delivery lot size that will be shipped to distribution centers in Aceh, Padang, Pekanbaru, Palembang and Medan. Based on Table 3 also shows the frequency of delivery from building material industry to each distribution center in a year. Table 3 shows the delivery frequency of nail products that compare with historical data in company.

**Table 3. Pegging Information each Distribution Center (continue)**

| Weeks | Aceh  | Padang | Pekanbaru | Palembang | Medan |
|-------|-------|--------|-----------|-----------|-------|
| 42    | 51.180|        |           |           |       |
| 43    |       |        |           |           |       |
| 44    |       |        | 67.225    | 42.950    |       |
| 45    | 51.180| 65.830 | 54.100    |           |       |
| 46    |       |        |           |           |       |
| 47    |       |        |           |           |       |
| 48    |       |        | 42.950    |           |       |
| 49    | 51.180|        |           |           |       |
| 50    |       | 65.830 | 54.100    | 67.225    | 42.950|
| 51    |       |        |           |           |       |
| 52    | 51.180|        |           |           |       |

4. **Conclusion**

Planning distribution activities in the form of DRP Worksheet has been clearly projected that ordering requirements in accordance with the delivery quantity calculation to meet the demand so there is no delay in fulfillment in the future. With the design of the distribution system with the DRP method, the company is expected to maintain the smooth and effective and efficient distribution activities so that the company can continue to have sustainable profits and savings in a market that fluctuates up and down. Using DRP method frequency of shipment decreased until 51.5% and inventory cost decreased until 20.4%.
References

[1] Fogarty D W, Blackstone J H and Hoffmann T R, 1991 Production and Inventory Management. (South-Western: 2nd Revised edition)

[2] Weiss H J and Gershon M E, 2002 Production and Operation Management

[3] Stenger A J and Cavinato J L, 1979 Production and Inventory Management 20 4 pp. 1-14

[4] Vollman T E, Berry W L and Whybark D C, 1984 Manufacturing Planning and Control System, Homewood (IL: Irwin)

[5] Sekhar J and Balasubramanian V, 2012 International Journal of Computer Trends and Technology 3

[6] I Rizky et al 2018 IOP Conf. Ser.: Mater. Sci. Eng. 434 012243

[7] Franks S IET JOURNALS & MAGAZINES  38-40

[8] Alessandri A, Gaggero M and Tonelli F, 2011 Transactions on Control Systems Technology 1075 1089

[9] Salmela H, Toivonen S and Scholliers J 2010 Transactions on Intelligent Transport Systems 307 317

[10] Martin A J 1983 Distribution Research Planning, Essex Junction (VT: Oliver Weight Publications Inc)

[11] Ho C J 1990 International Journal of Physical Distribution & Logistics Management 20 2 pp.3-8,

[12] Zipkin P H 2000 Foundations of Inventory Management (New York: McGraw-Hill)

[13] Rahmat R F, Nurmawan, Sembiring S, Syahputra M F, Fadli 2018 Adaptive neuro-fuzzy inference system for forecasting rubber milk production IOP Conference Series : Materials Science and Engineering 308(1), 012014

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