

Optimization of Planning and Scheduling Distribution Activities (Empirical Study at Packed Drinking-Water Distribution Company in Bali, Indonesia)

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ABSTRACT : Distribution planning and scheduling can affect the timeliness of product delivery and the amount of product inventory that will be distributed to consumers. Distribution Requirements Planning is one method that can be used to solve problems in a company's distribution activities. This research was conducted packed-drinking-water distribution company which is located in Bali, Indonesia. The period used is in December 2019 with a distribution process of 27 times. Forecasting is done using data in the period from September to November 2019. The results show a comparison that by using the Distribution Requirement Planning method the company can save a total distribution cost of IDR. 438,300 or equivalent to 5.66%.

KEYWORDS: *Distribution Planning, Distribution Scheduling, Distribution Requirement Planning (DRP), Forecasting, Lot Sizing*

I. INTRODUCTION

Consumers now prefer products in the form of goods or services that offer competitive features from the company (Dewi & Suprapti, 2018). The very tight business competition requires good production and distribution planning. Good production planning can guarantee the availability of raw materials and a smooth production process so that production targets can be achieved (Becker et al., 2016). Good production scheduling is necessary to ensure the delivery of products on time and quantity to consumers (Hardi & Sudarso, 2017).

In most products, the role of distribution and transformation networks is vital. Distribution activities are becoming increasingly important with many companies having to make direct deliveries to customers. To create a competitive advantage, companies can no longer rely on traditional ways of distributing their products (Abdelmotteleb et al., 2018). Distribution greatly determines the increase in the effectiveness and efficiency of a company because it involves scheduling and the level of costs required (Noroozi et al., 2018). Uncontrolled distribution planning and scheduling can cause major losses for the company and result in shortages or excess inventory in the warehouse (Firoozi et al., 2020). Besides, production planning and scheduling also affect the timeliness of product delivery to consumers so that complaints can be minimized (Ngoc & Nananukul, 2016). The problems most often encountered in this product distribution planning and scheduling system are too much product inventory, the product is in the wrong place, poor customer service, and lost sales due to out of stock (Rizkya et al., 2019).

One way to be able to control the distribution process is to prepare supplies as needed (Sembiring et al., 2019). Inventory can anticipate fluctuations in demand, but it can reduce costs. Inventory planning can be disrupted due to poor ongoing information processing (Yasa & Mandala, 2020), the result may be supply-related problems. The inventory of goods to be distributed must be managed properly so that no excess or deficiency can cause extra costs. Inventory has two costs in it (Reyes et al., 2018). The first is ordering cost and the second is carrying cost. To control inventory costs, the amount of inventory must be adjusted according to need. This inventory amount adjustment can be done using a method called forecasting (Fertsch, 2017).

After knowing the exact amount of inventory required, distribution planning and scheduling can be carried out (Pangestu, 2017). One of the methods of distribution planning and scheduling is the Distribution Requirements Planning (DRP) method (Wahyuningsih & Pradana, 2018). This method aims to plan how many products and when the delivery will be made for each distribution channel. Besides, the requirements required in one delivery are also considered so that they do not exceed the existing capacity in the company (Rizkya et al., 2018). The DRP table contains a lot of information that can help produce appropriate distribution planning and scheduling (Magdalena & Suli, 2019). The advantage of implementing the DRP method is that it can overcome the increasing demand in planning the decision to replenish product stocks (Nugroho et al., 2019). DRP is also able to estimate out of stock and plan product inventory to extend the period (Dayanty et al., 2020).

CV Amerta Nugraha Dewata is a company engaged in the distribution of drinking water with the Bali Water brand. This product from CV Amerta Nugraha Dewata is Reverse Osmosis (RO) water in gallons. CV Amerta Nugraha Dewata has a product distribution process starting from an internal distribution between factories to warehouses, then distributing the products to their direct consumers who are scattered in the Tabanan and Denpasar areas. Companies are required to be able to manage the planning and scheduling of distribution activities properly. However, the company still experiences several obstacles, such as the incompatibility of the amount of supply with demand and the timeliness of product delivery to consumers, which sometimes is not met. This will affect the costs incurred by the company in the process of distributing its products.

The use of the DRP method has been used in various research subjects, such as that done by Suradi et al. (2019) and Muttaqinet et al. (2017). From these results, it is known that the DRP method is more efficient and effective and can save overall costs compared to the distribution method applied by the company. Besides, Hardi & Sudarso (2017) and Sinulingga et al. (2016) also shows that the use of the DRP method is able to better coordinate distribution activity scheduling planning. Suryana & Faruk (2017) shows that the DRP method has no effect on distribution costs but can determine the number of product shipments so that the DRP method can be used in the company while still reviewing other factors because it can have a complex impact on the company's sustainability.

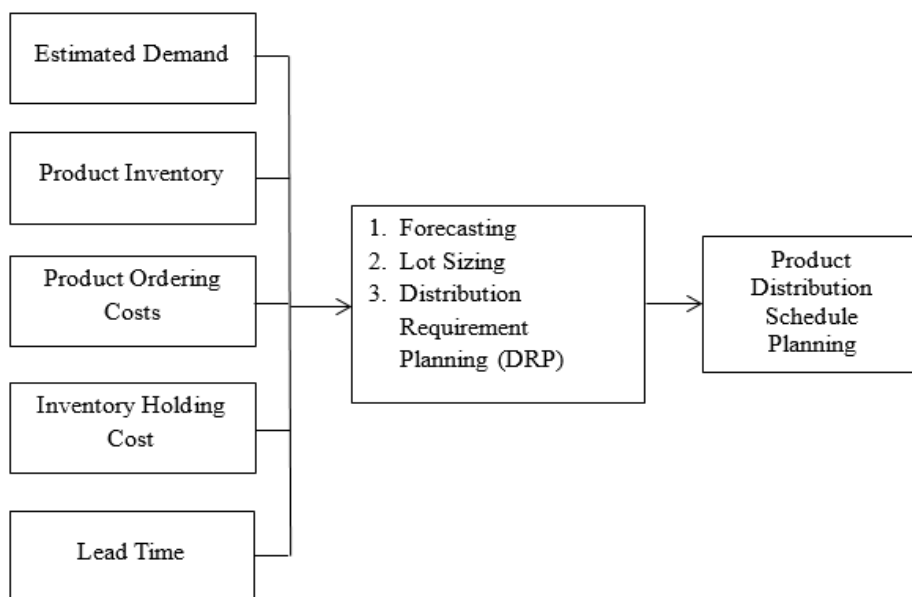


Fig. 1 Conceptual framework

II. RESEARCH METHODS

The first stage in this research is to collect data from the company. The data needed are data on the number of company product demand estimates, product inventory data, product ordering cost data, inventory storage cost data, and lead time from the company (Sutoni & Agustian, 2017). In the next stage, the data will be processed according to the planned sequence of data processing (Fu et al., 2018). The first data processing done is forecasting. Several forecasting methods will be used to process product demand forecast data. The results of the forecasting will be used to measure the lot (Lot Sizing). After finding the right lot size, data processing using the Distribution Requirement Planning method can be carried out. Some of the data that has been previously collected are also included in the DRP table (Herdiani & Kustiawan, 2017). The result of DRP table processing is a planning of scheduling the company's product distribution activities in one period (Gifari & Suliantoro, 2018). This research is a descriptive study using a quantitative approach. This research is a case study at CV Amerta Nugraha Dewata Tabanan which aims to determine the optimization of planning and scheduling of distribution activities in the company using the Distribution Requirement Planning method. This location was chosen because there were problems in the form of delays in delivery and unsuitable supplies that could affect costs in carrying out distribution activities. This study uses data from September to November 2019 to process and search for scheduling planning and total distribution costs for the 31-day period in December 2019. The data collection methods used in this study are observation and interviews.

III. RESULTS AND DISCUSSION

Forecasting

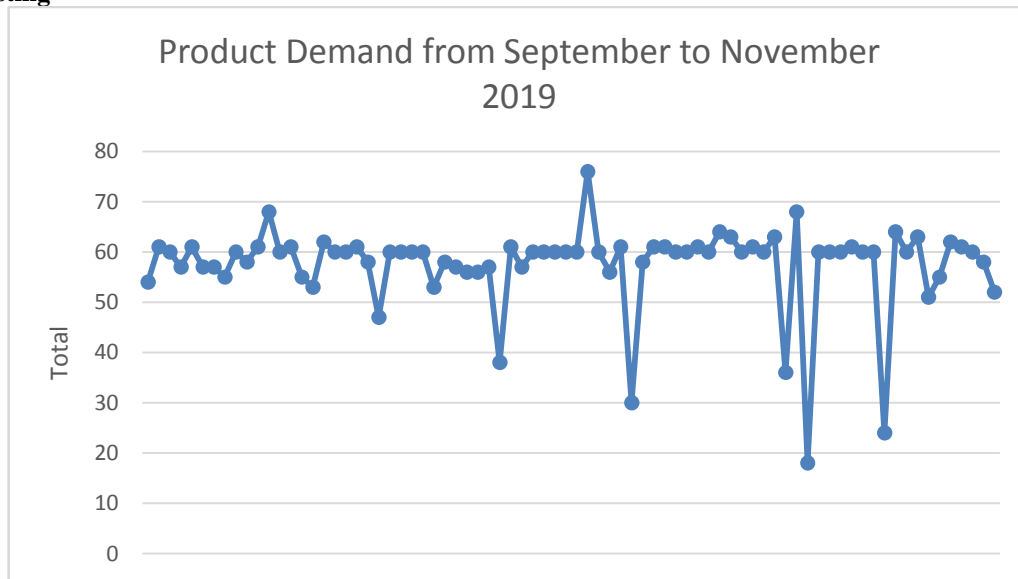


Figure 1 . Forecasting Data Patterns of CV Amerta Nugraha Dewata from September to November 2019

It can be concluded that the demand for CV Amerta Nugraha Dewata from September to November 2019 has a horizontal data pattern. After knowing the shape of the data pattern, what is next is done is to determine the forecasting methods to be used. In this study, several forecasting methods were used : the moving average method (k = 3, k = 5, and k = 7) and the single exponential smoothing method. Then after getting the forecasting calculation, the error or error of each forecasting method will be calculated and the smallest error value will be selected. The error calculation method used is MAPE (Mean Absolute Percentage Error), MAD (Mean Absolute Deviation), and MSD (Mean Squared Deviation). This forecasting and error calculation process will be carried out with the help of Microsoft Excel and Minitab applications. Forecasting calculations using various methods are attached in the appendix. The following are the results of the error calculation for each forecasting method.

Table 1. Level of Forecasting Error

| No | Forecasting Method | MAPE | MAD | MSD |
|----|------------------------------|---------|--------|---------|
| 1 | Moving Average k=3 | 15.192 | 6.436 | 104.101 |
| 2 | Moving Average k=5 | 14.8754 | 6.0740 | 97.7792 |
| 3 | Moving Average k=7 | 14.4048 | 5.8209 | 89.7899 |
| 4 | Single Exponential Smoothing | 12.1283 | 4.7308 | 72.6795 |

Based on table 1, it can be seen that the single exponential smoothing method has the smallest MAPE, MAD, and MSD values compared to other methods, namely 12.1283; 4,7308; and 72.6795. Therefore, the single exponential smoothing method was chosen as the forecasting method that will be used to estimate demand in December 2019. In a one week period, the distribution process is only carried out 6 times (off on Saturdays). So, the distribution in December 2019 was carried out 27 times.

Table 2. Demand-Forecast for December 2019 Using the Single Exponential Smoothing Method

| Date | Forecast | Date | Forecast | Date | Forecast |
|------|----------|------|----------|------|----------|
| 1 | 58 | 11 | 58 | 22 | 58 |
| 2 | 58 | 12 | 58 | 23 | 58 |
| 3 | 58 | 13 | 58 | 24 | 58 |
| 4 | 58 | 15 | 58 | 25 | 58 |
| 5 | 58 | 16 | 58 | 26 | 58 |
| 6 | 58 | 17 | 58 | 27 | 58 |
| 8 | 58 | 18 | 58 | 29 | 58 |
| 9 | 58 | 19 | 58 | 30 | 58 |
| 10 | 58 | 20 | 58 | 31 | 58 |

Lot Sizing

Table 3. Total Lot Sizing Fee for December 2019

| No | Lot Sizing | Total Cost |
|----|-------------------------|---------------|
| 1 | Lot for Lot | IDR 1.498.700 |
| 2 | Fixed Order Quantity | IDR 1.937.000 |
| 3 | Economic Order Quantity | IDR 1.942.200 |

The lot for lot method has the smallest total cost compared to other methods, which is IDR 1,498,700. Therefore, the lot for lot method was chosen as the lot sizing method used for calculating the company's Distribution Requirements Planning in December 2019.

Safety Stock

Safety stock is an inventory that protects the company from uncertainty in demand, in other words, safety stock is the minimum stock that must be available and is only used when the company is in higher demand than usual. However, because the lot sizing method that produces the lowest cost is the lot for lot method, the procurement of safety stock is not required in the company. Therefore, the amount of safety stock is not calculated.

Distribution Requirement Planning

CV Amerta Nugraha Dewata carried out the distribution process 27 times during December 2019. The company consistently distributes 58 gallons of its products spread across various regions. Besides, the company orders products 26 times, where one order is 28 gallons, and the rest orders 58 gallons. The company also does not have inventory in the warehouse during the period December 2019 except on the 1st, which amounts to 30 gallons. Based on this explanation, the total distribution costs of CV Amerta Nugraha Dewata using the Distribution Requirement Planning method are as follows:

$$\begin{aligned}
 \text{Total ordering costs} &= 17,500 + (28 \times 400) + (17500 \times 2 \times 25) + (58 \times 400 \times 25) \\
 &= \text{IDR } 1,483,700 \\
 \text{Total storage cost} &= 30 \times 500 \\
 &= \text{IDR } 15,000 \\
 \text{Distribution costs} &= 27 \times 215,000 \\
 &= \text{IDR } 5,805,000 \\
 \text{Total distribution costs} &= \text{Total ordering costs} + \text{Total storage costs} + \text{Distribution costs} \\
 &= \text{IDR } 1,483,700 + \text{IDR } 15,000 + \text{IDR } 5,805,000 = \text{IDR } 7,303,700
 \end{aligned}$$

Table 4. Comparison of Total Distribution Costs for December 2019

| | Method used by Company | Distribution Requirement Planning |
|--------------------|------------------------|-----------------------------------|
| Order fee | IDR 1,125,000 | IDR 1,483,700 |
| Storage costs | IDR 812,000 | IDR 15,000 |
| Distribution costs | IDR 5,805,000 | IDR 5,805,000 |
| Total | IDR 7,742,000 | IDR 7,303,700 |

The total distribution cost at CV Amerta Nugraha Dewata using the company-owned method is IDR 7,742,000, with details of the order fee of IDR 1,125,000, a storage fee of IDR 812,000, and a distribution fee of IDR 5,805,000. Meanwhile, the total distribution cost using the Distribution Requirement Planning method is IDR 7,303,700, with details of the ordering cost of IDR 1,483,700, the storage cost of IDR 15,000, and distribution cost of IDR 5,805,000. Therefore, it can be concluded that the distribution process using the Distribution Requirements Planning method can reduce the company's distribution costs by up to 5.66%.

Implications of Research Results

Based on the results of this study, excess product inventory occurs due to the absence of planning in determining distribution capacity. This results in an investment that is embedded in product inventory stored in the warehouse and results in increased storage costs or waste. Besides, the inaccuracy of delivery schedules on the predetermined paths makes the distribution process not run as planned. This research responds to this problem through the application of the Distribution Requirements Planning (DRP) system starting from the forecasting process and lot sizing into the distribution process.

In the forecasting process, it can be seen that the company's gross needs in the calculated period are related to the products to be distributed. This gross need can be determined by using product demand data in the previous period. After the forecasting process, what is next is done is the lot sizing process. The lot sizing process is carried out to determine the description for the company regarding how many products must be ordered so that distribution needs are met and there is no excess or shortage of inventory. After knowing how many gross needs and also the number of products that must be ordered every time you place an order, then

what is next is done is to determine the safety stock. However, because the lot sizing method used is the lot for lot method, safety stock is not needed and is not calculated.

The final process of the DRP in this study is to enter all the necessary data into the DRP table which is then calculated and produces a product distribution schedule to consumers. In this process, the company can find out the right time to place an order for products to the factory along with all distribution scheduling to consumers. After knowing the number of products every time you place an order, how many times you place an order for products, how much inventory is in the warehouse, and how many times do the distribution process, you can calculate the total distribution cost. Furthermore, the results of the calculation of the total distribution costs using the DRP method and the total distribution costs using the company-owned method can be compared.

IV. CONCLUSION

Determination of the gross drinking water needs of Bali Water which is carried out by the company has not used the correct forecasting method so that the company cannot accurately estimate market demand. By using the forecasting method, namely the Moving Average method ($k = 3$, $k = 5$, and $k = 7$), and the Single Exponential Smoothing method, it can be estimated that market demand with accuracy or the smallest error can be estimated. After the calculation of forecasting using the two methods mentioned above, the Single Exponential Smoothing method was chosen to be the most appropriate method to be used as a forecasting method in the company because it has the smallest standard error. The lot sizing process or determining the size of the order in this study uses three lot sizing methods, namely Lot For Lot, Fixed Order Quantity, and Economic Order Quantity. After calculating the lot sizing using the three methods mentioned above, the Lot For Lot method becomes the method with the smallest total cost of IDR 1,498,700. The Lot For Lot method was chosen to be the most appropriate method to be applied in the company and can provide cost savings for the company. Companies that have used the lot for lot method do not require product storage or safety stock to reduce storage costs. After calculating the distribution costs of the company using the DRP method, it is known that the total cost generated by using the DRP method has a difference of 5.66% compared to the method used by the company

CV Amerta Nugraha Dewata should do demand forecasting using the Single Exponential Smoothing method for the process of determining the gross need for its gallon drinking water products. This is intended as a guide for companies in the process of determining the capacity of orders at the factory following the demands and needs so that there is no excess or shortage of product inventory. CV Amerta Nugraha Dewata should also use the right lot sizing method to determine the size of the order for Bali Water gallon drinking water products. The results of this study provide suggestions and input for companies to use the Lot For Lot method as a method of determining the correct order size or product lot size. CV Amerta Nugraha Dewata should not have inventory or safety stock in the warehouse to reduce storage costs at the company. This is because by using the Lot For Lot method the company is expected not to have products stored in warehouses

For further research, it can be carried out at different companies by adding or replacing forecasting methods and lot sizing as a comparison to determine which method is better in streamlining the total cost of distribution.

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