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# Supply Chain Analysis Using Distribution Requirement Planning (DRP) Based On Bullwhip Effect Parameter (Case Study: Ud. Narwastu, Surabaya)

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***ABSTRACT***

*Narwastu Firm is a company in Surabaya which produces traditional body care and aromatherapy. During the product distribution, this company encounters many mistakes such as inappropriateness between Purcashing Order (PO) from distributors/consumers and the goods delivered due to bullwhip effects. Therefore, this research aimed at reducing the bullwhip effects by implementing Collaborative, Planning, Forecasting, and Replenishment (CPFR) method and investigating a lot sizing technique for producing minimum distribution cost by Distribution Requirement Planning (DRP) method in order to regulate order and plan a certain distribution activity. The research results demonstrated that the bullwhip effect values after CPFR improvement of two products that could be repaired were 1.0 for Body Scrub Goats Milk Balibloom (BSC GM BB) 200 gr and 0.96 for Body Mist Sparkling White (BM SW) 60 ml. Meanwhile, the calculations by Distribution Requirement Planning (DRP) method with Economic Order Quantity (EOQ) method got the plans for ordering Body Scrub Lightening (BSC LIGHT) 200 gr by 182 times with total cost IDR 96,886,476 and Body Lotion Lightening (BL LIGHT) 250 ml by 235 times with total cost IDR 125,873,816.*

***Keywords:*** *Bullwhip Effect, CPFR, DRP, Lot*

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**ABSTRAK**

UD. Narwastu merupakan perusahaan yang bergerak di bidang produksi aromaterapi dan *body care* tradisional yang saat ini berada di Surabaya. Dalam proses pendistribusian produk yang dilakukan masih banyak kesalahan yang sering terjadi yaitu ketidaksesuaian antara *Purcashing Order* (PO) dari distributor/konsumen dengan barang yang di kirimkan, itu terjadi akibat *bullwhip effect*. Maka dari itu, penelitian ini bertujuan untuk mengurangi terjadinya *bullwhip effect* dengan metode *Collaborative, Planning, Forecasting, and Replenishment* (CPFR) serta mengetahui teknik *lot sizing* yang menghasilkan biaya distribusi minimum dengan metode *Distribution Requirement Planning* (DRP) yang dapat mengatur pemesanan, dan merencanakan suatu aktivitas pendistribusian. Dari penelitian yang telah di lakukan, didapatkan hasil nilai *bullwhip effect* menggunakan perbaikan CPFR terdapat dua produk yang dapat diperbaiki yaitu produk *Body Scrub Goats Milk Balibloom* (BSC GM BB) 200 gr dengan nilai sebesar 1,0 *Body Mist Sparkling White* (BM SW) 60 ml dengan nilai sebesar 0,96. Dari perhitungan menggunakan metode *Distribution Requirement Planning* (DRP) dengan metode *Economic Order Quantity* (EOQ) didapatkan perencanaan pemesanan untuk produk *Body Scrub Lightening* (BSC LIGHT) 200 gr sebanyak sebanyak 182 kali dengan total biaya sebesar Rp. 96.886.476 dan produk *Body Lotion Lightening* (BL LIGHT) 250 ml sebanyak 235 kali dengan total biaya sebesar Rp. 125.873.816.

***Kata kunci:*** *Bullwhip Effect*; CPFR; DRP; *Lot*.

## INTRODUCTION

The ability of a company to deliver their products with the right amount and quality, at the right time, is known to increase their competitive advantages. Therefore, companies are certainly

required to improve their performance in regulating the supply chain, especially in term of product distribution [1]. Distribution planning is one important key to optimally control and run the distribution process [2].

However, the bullwhip effect phenomenon in the distribution process is one of the main challenges for companies in order to increase their supply chain performance [3]. Bullwhip effect is defined as a phenomenon that occurs due to amplification or distortion of demand which shows that the number of orders to suppliers is greater than sales, resulting in a distortion from upstream to downstream [4]; [5]. The bullwhip effect will cause an irregular production schedule, which will be resulting in very sharp fluctuations in the upstream chain. If this happens continuously, it will have a negative impact on the company and have major implications for increasing production and distribution costs [6].

This study focuses on the sales division of UD. Narwastu, Surabaya. The company produces various types of body care products. Based on observations, it is known that there are five products that experience a bullwip effect, namely Body Mist Sparkling White, Body Scrub Lightening 200 gr, Body Scub Goats Milk Balibloom 200 gr, Body Mist Secret Vanilla 60 ml, and Body Lotion Lightening 250 ml. This research attempts to improve the bullwhip effect by using the Collaborative, Planning, Forecasting, and Replenishment (CPFR) method [7]. In addition, we also carry out an analysis using the Distribution Requirements Planning (DRP) method to set the optimal ordering lot size [8].

The objectives of this study are to: 1.) determine the value of the bullwhip effect of the five products at UD. Narwastu; 2.) determine the value of the bullwhip effect after improvement using the CPFR method; 3.) determine the amount of safety stock results for optimal inventory; and 4.) provide recommendations for the most efficient distribution planning using the DRP method based on the calculation of the optimal lot size.

## LITERATURE STUDY

### Supply Chain Management (SCM)

Supply Chain Management (SCM) is defined as an integrated flow management within an organization or company, starting from suppliers, manufacturers, warehouse, transportation, distribution, and retail that allows goods or products to arrive at the hands of customers at good quality, quantity, and time, as well as a minimum cost, so that customer satisfaction can be increased [9].

### Bullwhip Effect

The bullwhip effect is a phenomenon in the supply chain where demand is much greater than the sales of a company, resulting in market inability (distortion) at a higher level chain [10]. This may result in a greater variation in demand. Bullwhip effect parameters can be calculated using the following equation [7]:

$$BE = \frac{CV_o\,(Order)}{CV_d\,(Demand)} \quad \text{.....(1)}$$

$$CV_d = \frac{\alpha(Demand)}{\mu(Demand)} \quad \text{.....(2)}$$

$$\mu = \frac{\sum(X_i)}{n} \quad \text{.....(3)}$$

$$CV_o = \frac{\alpha(order)}{\mu(order)} \quad \text{.....(4)}$$

$$\alpha = \sqrt{\frac{\sum(x_i,\ldots,x_{n-\mu})^2}{n-1}} \quad \text{.....(5)}$$

Notations:

| | | |
|---|---|---|
| $BE$ | = | Bullwhip effect parameter |
| $CV_d(demand)$ | = | Demand variance coefficient |
| $CV_o(order)$ | = | Order variance coefficient |
| $\alpha(demand)$ | = | Standard deviation of the demand |
| $\mu(demand)$ | = | Average demand |
| $\alpha(order)$ | = | Standard deviation of the order |
| $\mu(order)$ | = | Average order |
| $X_i$ | = | Data-$i$ |
| $n$ | = | The number of the data |

Therefore, a BE value ≥ 1 indicates an amplification of the demand.

**Collaborative, Planning, Forecasting, and Replenishment (CPFR)**

The CPFR method is used to reduce the difference between forecasts made by two or more actors in the supply chain, and then simultaneously determine an optimal replenishment policy [7]. The purpose of CPFR itself is to reduce inventory levels and improve customer service.

**Inventory**

Inventory is a company's ability to manage and regulate every stock of goods to be used, such as raw materials, semi-finished goods or finished goods, so that market conditions are stable and do not experience fluctuation [11].

**Lot Sizing Technique**

*Economic Order Quantity (EOQ)*

EOQ is used to determine the optimal lot size in order to minimize holding costs, ordering costs, and shortage costs [12]. The EOQ is calculated using the following equation.

$$EOQ = \sqrt{\frac{2DS}{h}} \quad \text{.....(6)}$$

Notations:

| | | |
|---|---|---|
| $EOQ$ | = | Economic order lot size |
| $D$ | = | Estimated demand for a certain period of time |
| $S$ | = | Ordering cost |
| $h$ | = | Holding cost |

*Least Unit Cost (LUC)*

The LUC method is used to determine the optimal lot size decision based on the lowest unit cost of each lot size to be selected [13]. The calculation for LUC is based on the following equation:

LUC = Unit purchasing cost + Unit holding cost …..…….. (7)

**Distribution Requirement Planning (DRP)**

Distribution Requirements Planning (DRP) is a method used to plan the distribution needs of a product from producers to consumers or from distributors to retailers [14]. The procedure of the DRP method is given as follows [15]:

1. The gross requirement or the demand forecast is obtained from the forecasting result.
2. Based on the results of the forecast, calculate the Time Phased Net Requirement which identifies the net product requirements. The following is the formula for calculating the net requirement:

Net Requirement = (Gross Requirement + Safety Stock) – (Schedule Receipt + Previous Period Projected On Hand) …….. (8)

3. The recorded net requirements are those that have positive values. Then, we will get a Planned Order Receipt for the amount of the Net Requirement (certain lot size) in that period.
4. Determine the time at which the company must carry out the order process for the product (known as a Planned Order Release) by reducing the scheduled time for Planned Order Receipt with the Lead Time.
5. Finally, calculate the projected on hand for that period. Here's the formula for calculating the projected on hand:

Projected On Hand = (The Previous Period Projected On Hand + Schedule Receipt + Planned Order Receipt) - (Gross Requirement) ….. (9)

## RESEARCH METHODS

This research was conducted with the following methodology: **Problem Identification and Determination of Research Objectives** is a stage that aims to explain the background of this research and the objectives to be achieved. **Data Collection and Processing**, at this stage the data collection needed during the research process is carried out. The data obtained will be processed with appropriate methods in an effort to achieve the goals that have been set in the previous stage. **Results Analysis and Interpretation**, at this stage analysis and discussion will be carried out related to the results that have been obtained. Data analysis is a continuation of data collection and processing to find out the findings and managerial insights from the research. **Conclusion and Suggestion**, the results obtained from the data processing and analysis will be used to draw conclusions in order to obtain answers to the problem formulation and objectives to be achieved. The methodology is represented by the following diagram.

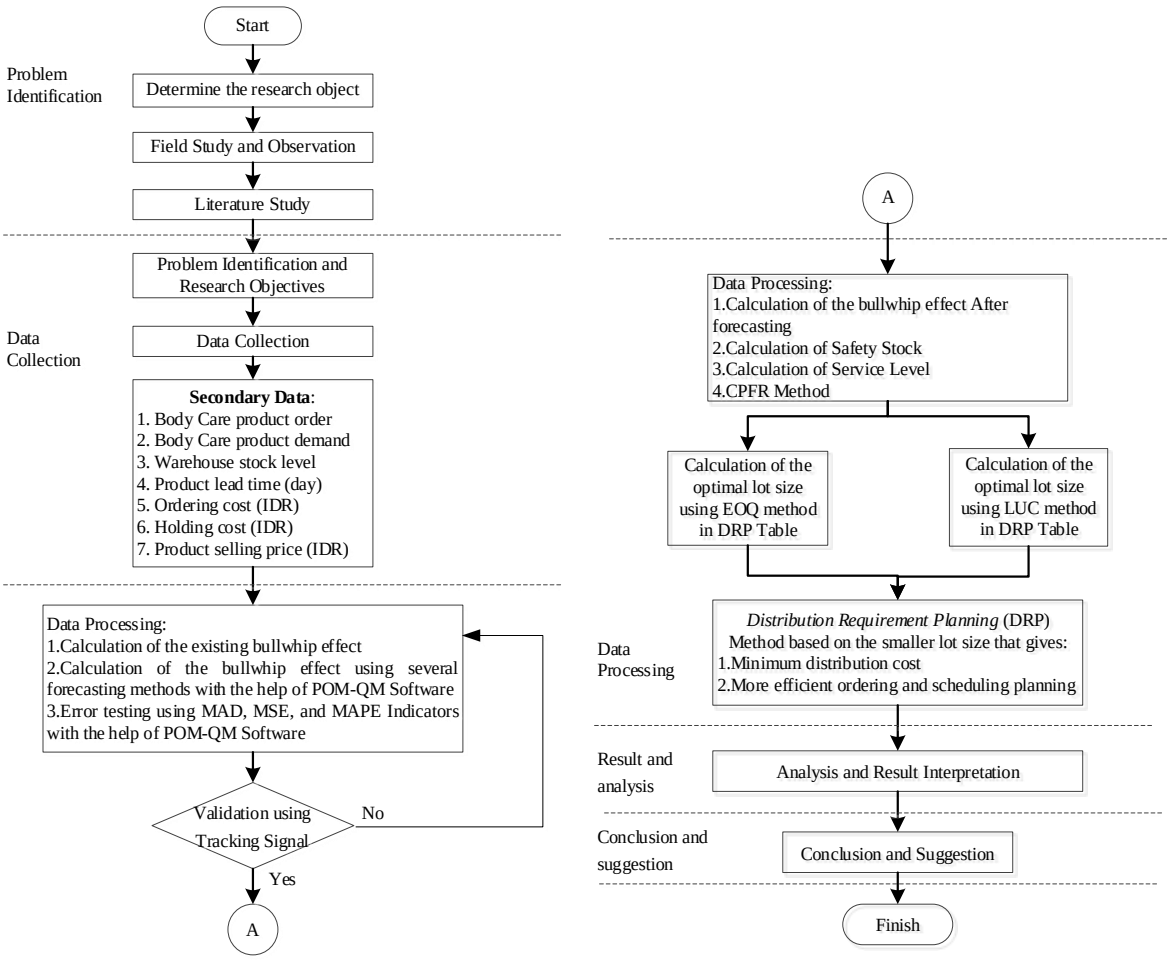


Figure 1. Research Methodology.

## RESULT AND DISCUSSION

### Bullwhip Effect

Based on the calculations that have been done, it is known that four of the five products in UD. Narwastu are experiencing bullwhip effect. The value of the bullwhip effect is obtained from the quotient between the sales and the demand variance coefficients. The results of the bullwhip effect calculation for each product are shown in the following table.

Table 1. Bullwhip Effect Calculation in UD. Narwastu

| Product Type | Demand | | | Order | | | BE Value | Amplification (yes/no) |
|---|---|---|---|---|---|---|---|---|
| | Average | Standard Deviation | $CV_d$ | Average | Standard Deviation | $CV_o$ | | |
| BSC GM BB | 343.83 | 157.17 | 0.46 | 304.17 | 397 | 1.31 | 2.8 | Yes |
| BSC LIGHT | 170.17 | 76.67 | 0.45 | 118.75 | 79.30 | 0.67 | 1.5 | Yes |
| BM SW | 497.41 | 633.42 | 1.27 | 350.67 | 645.64 | 1.84 | 1.4 | Yes |
| BL LIGHT | 254.33 | 223.27 | 0.88 | 190.00 | 229.07 | 1.21 | 1.4 | Yes |
| BM SV | 743.3 | 2,612.00 | 3.51 | 648.00 | 1,366.84 | 2.11 | 0.6 | No |

### Collaborative, Planning, Forecasting, and Replenishment (CPFR)

In order to improve the value of the bullwhip effect, improvements were made using the CPFR method and the results are shown in Table 2.

Table 2. Bullwhip Effect Calculation after Improvement with CPFR.

| Product Type | Demand | | | Order | | | BE Value | Amplification (yes/no) |
|---|---|---|---|---|---|---|---|---|
| | Average | Standard Deviation | $CV_d$ | Average | Standard Deviation | $CV_o$ | | |
| BSC GM BB | 308.00 | 32.01 | 0.10 | 312.00 | 31.40 | 0.10 | 1.0 | No |
| BSC LIGHT | 170.00 | 24.79 | 0.15 | 146.00 | 25.00 | 0.17 | 1.13 | Yes |
| BM SW | 790.00 | 262.00 | 0.33 | 799.00 | 254.00 | 0.32 | 0.96 | No |
| BL LIGHT | 263.00 | 7.44 | 0.03 | 264.43 | 10.54 | 0.04 | 1.33 | Yes |

From table 2, the CPFR method can improve the value of the bullwhio effect, where initially the four products experienced amplification, reduced to 2 products only. So, the two products will be continued to the calculation using the Distribution Requirements Planning (DRP) method so that order scheduling planning can be carried out at a more efficient cost.

### Safety Stock

From the forecasting results, we obtain the optimal inventory level for the four products at UD. Narwastu, by adding the value of the safety stock for the four products. The optimal safety stock for each product is given in Table 3 below.

Table 3. Safety Stock of Each Product Based on its Bullwhip Effect Value

| Product Type | Safety Stock |
|---|---|
| BSC GM BB | 4 unit |
| BSC LIGHT | 3 unit |
| BM SW | 11 unit |
| BL LIGHT | 2 unit |

**Lot Sizing Method**

The products analyzed using lot sizing calculations and the DRP method are products that still experience a bulwhip effect, namely 200 gr Body Scrub Lightening (BSC LIGHT) and 250 ml Body Lotion Lightening (BL LIGHT). The required data such as warehouse inventory data, product prices and other costs are given in Table 4 and 5 below.

Table 4. Holding Cost of UD. Narwastu

| Product Type | Holding Cost | |
|---|---|---|
| | Unit holding cost | Lead time |
| BSC LIGHT | IDR 5,193 | 5 days |
| BL LIGHT | IDR 5,809 | 5 days |

Table 5. Ordering Cost of UD. Narwastu

| Type of Cost | Value |
|---|---|
| Cost of loading/unloading/expedition | IDR 4,000/Kg |
| Call fee | IDR 220,000 |
| Receipt documentation | IDR 3,000 |
| Courier incentive fee | IDR 500,000 |

The calculation of EOQ for BSC LIGHT and BL LIGHT products are given as follows:

1. EOQ for Body Scrub Lightening (BSC LIGHT) 200 gr

$$EOQ = \sqrt{\frac{2DS}{h}} = \sqrt{\frac{2 \times 1{,}710 \times 727{,}000}{5{,}193}} = \sqrt{39{,}888.31} = 199.72 \approx 200\ units/month$$

2. EOQ for Body Scrub Lotion Lightening (BL LIGHT) 250 ml

$$EOQ = \sqrt{\frac{2DS}{h}} = \sqrt{\frac{2 \times 3{,}152 \times 727{,}000}{5{,}809}} = \sqrt{65{,}744.93} = 256.41 \approx 256\ units/month$$

Furthermore, the calculations of LUC are done for BSC LIGHT and BL LIGHT products by selecting the smallest costs incurred in each period, so that the lot size is obtained based on cumulative demand.

**Distribution Requirement Planning (DRP)**

The DRP procedure for calculating the EOQ lot size of BSC LIGHT products for the January 2019 period is shown below.

*a. Gross Requirement (GR)*
The GR calculation for DRP in January 2019 is taken from the results of forecasting demand for January in the first period, which is 155 units.

*b. Schedule Recipe (SR)*
This SR is zero because the raw materials used come from suppliers.

*c. Project On Hand (POH)*
The following are the steps to calculate POH in DRP in January 2019 in the first period:

$$POH = 340 - 155 + 0 = 185$$

Then, POH for the next period is calculated in the same way.

*d. Net Requirements (NR)*
The following is the calculation of NR in the DRP for the 3rd period of January 2019. Since the 1st and 2nd periods can still be fulfilled, hence the order for the next period is calculated using the following equation.

$$NR = (155 + 5) - (0 + 30) = (155 + 5) - (0 + 30) = 160 - 30 = 130$$

Then, NR for the next period is calculated in the same way.

*e. Planned Order Receipts (PO Rec)*
The following is the calculation of PO Rec in DRP for the 3rd period of January 2019:

$$PO\ Rec = Lot\ size\ in\ a\ certain\ period = EOQ = 200\ units$$

PO Rec for the next period is calculated in the same way.

*f. Planned Order Release (PO Rel)*

$$PO\ Rel = PO\ Rec = 200\ units$$

*g. Holding Cost*
The holding cost in the first period is obtained from the calculations that have been done for the BSC LIGHT product, which is IDR 5,193, and the calculation for the next period can be calculated as:

$$Holding\ cost = IDR\ 5{,}193 \times 185 \div 30 = IDR\ 842$$

Holding cost for the next period is calculated in the same way.

*h. Ordering Cost*
Ordering cost is the total of cost component related to product distribution. Ordering cost in UD. Narwastu is calculated as IDR 727,000. Ordering costs are always charged when a distributor, reseller, or retailer places an order.

The calculation of the next period as well as for the BL LIGHT product are done using the same procedure. After calculating the DRP using the EOQ and LUC methods, the total number of orders and costs incurred for the distribution of the two products is obtained. The results of the comparisons between the two lot sizing methods used are shown in Table 6 below.

Table 6. DRP Result Comparison of the Two Lot Sizing Methods

| Product Type | EOQ | | LUC | |
|---|---|---|---|---|
| | Annual Orders (times/year) | Annual Total Cost (IDR/year) | Annual Orders (times/year) | Annual Total Cost (IDR/year) |
| BSC GM BB | 182 | 98,668,476 | 200 | 118,110,638 |
| BSC LIGHT | 235 | 125,873,816 | 249 | 131,648,293 |

From Table 6 above, we understand that lot sizing using EOQ method give more economical result than LUC method. Therefore, the recommended lot sizing method for planning and scheduling orders at UD. Narwastu is EOQ method.

## CONCLUSION

Based on this research, it is known that the current bullwhip effects for Body Scrub Goats Milk BaliBloom (BSC GM BB) 200 gr product is 2.8, Body Scrub Lightening (BSC LIGHT) 200 gr product is 1.5, Body Mist Sparkling White (BM SW) 60 ml product is 1.4, and Body Lotion Lightening (BL LIGHT) 250 ml product is 1.4. Using the CPFR method, we understand that out of the four products that experienced bullwhip effect, there are two products that can be improved, which are Body Scrub Goats Milk Balibloom (BSC GM BB) 200 gr with the value of 1.0 and Body Mist Sparkling White (BM SW) 60 ml with the value of 0.96, which means there is no amplification.

The optimal inventory can be added with safety stock into each of the four products. BSC GM BB products have a safety stock of 4 units, 3 units of BSC LIGHT products, 11 units of BM SW products, and 2 units of BL LIGHT products. The results of DRP method show that scheduling of orders using the EOQ method is the most economical. The optimal BSC LIGHT product orders are 182 times a year with a total cost of IDR 96,886,476, whereas the optimal BL LIGHT product orders are 235 times a year with a total cost of IDR 125,873,816.

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