The evaluation of bullwhip effect on distribution system of a supply chain using centralized demand information method

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Abstract Bullwhip effect is a crucial problem in a supply chain. Bullwhip effect is distortion information between inventory and demand in the whole supply chain stages. This problem has not solved in the business recently, although there are many studies discussed this issue. Bullwhip effect gives a negative impact on the performance of the inventory system. This impact can reduce using Centralized Demand Information (CDI). This research aims to analyze the bullwhip effect that happens in between a manufacturer, distribution, and retailers to minimize inventory cost. This research aim is achieved by: i) Calculating the amount of bullwhip effect of PT. X that occurs in the bottled drinking water distribution system; ii) Implement the centralized demand information method to reduce the bullwhip effect on the supply chain water supply network; iii) Comparing inventory costs before and after cutting the bullwhip effect on the supply chain. The data such as time series, data in 12 periods (monthly), data on raw material procurement, holding cost and stockout costs. The reason for using CDI for calculating the bullwhip effect and Economic Order Quantity (EOQ) to calculate the inventory cost. Research findings show that using CDI will decrease the bullwhip effect and the impact is reducing inventory cost.

1. Introduction
The existence of various parties involved and related in the product flow from producers to consumers will form a system known as the supply chain system. The function of the supply chain to provide the right product or service, at the right place, the right time and the desired conditions. For the supply chain system to work correctly, management called Supply Chain Management (SCM) is needed. After the manufacturing process is complete, inventory in the form of finished goods will move from the factory warehouse to the consumer through a series of distribution channels and facilities. Product flow starts from the warehouse of finished goods, distribution warehouses and retailers to consumers. Supply Chain Management is applied to integrate manufacturers, suppliers, retailers, and sellers efficiently and effectively so that products can be produced and distributed with the right amount and minimum overall cost.

In supply chain management, information occupies an important role. Good coordination and information flow between the parties in each element of the supply chain network is needed to maintain the effectiveness of a supply chain that is built. Every party involved in the supply chain manages information to estimate inventory levels. Change (distortion) of consumer demand results in a series of effects that will disrupt the supply chain. In this situation, the company does not have
accurate request information. As a result, there is an excess or lack of product numbers, increased storage costs, and stockout costs. The problem of the bullwhip effect also affects the value of inventory of materials produced directly by the manufacturer. The higher the bullwhip that occurs, the higher the costs incurred by the company. In connection with the losses incurred, the company needs to calculate and evaluate the magnitude of the bullwhip effect and find a solution to reduce the bullwhip effect. One method used to assess the bullwhip effect is by using Centralized Demand Information (CDI). The principle in this CDI is to focus request information, which is to make information on customer requests available at each stage of the supply chain. The use of Centralized Demand Information (CDI) is expected to provide better solutions for companies to reduce the problem of the bullwhip effect to maximize profits.

2. Literature review
The discussion of the supply chain business area attracted many studies in the last few decades. This shows that the problems in the supply chain affect the performance of companies involved in the supply chain network [1]. The scope of the supply chain is various parties that interact with each other consisting of suppliers of raw materials, manufacturers, distributors, and retailers who together transform raw materials into goods or services delivered to consumers. The Bullwhip effect is a problem that arises in the supply chain. According to [2] the bullwhip effect began to become the attention of the researchers in the late 1950s. Bullwhip effect firstly was investigated by [3] which then continued by several researchers [4],[5] and [6]. The pioneering researchers have recorded the existence of bullwhip effect on the supply chain. Logistics executives first used the term bullwhip effect at Procter & Gamble (P&G) examined the order patterns for one of their best-selling products. Its sales at retail stores were fluctuating, but the variabilities were indeed not excessive. However, as they examined the distributors' orders, the executives were surprised by the degree of variability. When they looked at P&G's orders of materials to their suppliers, they discovered that the swings were even higher. At first glance, the variabilities did not make sense. While the consumers, consumed the product at a steady rate, the demand order variabilities in the supply chain were amplified as they moved up the supply chain.

The research on the bullwhip effect in the recent years, such as the study by [11],[7],[8],[9],[10],[11],[12] and [13]. The scope of the research they are doing is evaluating the bullwhip effect that occurs in the supply chain network. The research that analyzes the bullwhip effect in university governance was conducted by [1]. This research has revealed that subject to a specific condition, a similar bullwhip effect phenomenon may happen in university governance. The method of identifying the occurrence of the bullwhip effect and the magnitude of the bullwhip effect. The average demand quantity deviation ratio in each chain is by calculating (average deviation ratio of the quantity of demand at the retailer to the average amount of demand in the consumer or the average deviation ratio the average amount of demand on an agent or wholesaler for the average deviation of quantity of demand at retailers, and so on to the end of the supply chain, that is, the supplier). Another research was that used the same method was done by [7]

To identify and measure bullwhip effect, [14] and [2] using a variance ratio (variance is the square of the standard deviation), whereas [15] and [16] use ratio coefficient of variation. It was found that there ware that there was no significant difference in both the measurement method [14].

Some researchers suggest that the primary cause of the bullwhip effect is demand forecast updating, non-zero lead time, order batching, supply shortages and price fluctuations [2]. The causes of, bullwhip effect are analyzed by [9], and the reducing measure is discussed in this study. The other paper, [12] studies relation of multi-terminals’ demand correlation and bullwhip effect in a two-stage supply chain with two retailers. Under centralized or decentralized information. [10] In the paper simulated a simple three-stage supply chain using seasonal (SM) and deseasonalized (DSM) time series of the market demand data in order to identify, illustrate and discuss the impacts of different level constraints on the bullwhip effect, is discussed in [13] evaluating the contribution of in-line metrology to mitigate bullwhip effect in internal supply chains. The analysis substantiated that lead
time can be reduced significantly, the output can be increased and bottlenecks better identified. The research found that metrology solutions support well-established countermeasures to minimize the undesirable effects of quality oscillations, it was also found that such as the bullwhip effect even within a single company.

Reduction of the bullwhip effect can be made if the cause is well understood by the parties in the technical supply chain or the principle approach must be following the cause. Understanding the causes of the bullwhip effect will lead to solutions to reduce the bullwhip effect. The solution to reducing the bullwhip effect is to reduce uncertainty by centralizing the information system, reducing variables, reducing lead times and building strategic cooperation between parties in the supply chain [17]. The paper conducted by [11] propose an optimization model to mitigate the bullwhip effect in a two-echelon supply chain. The objective function is to minimize the sum difference between the actual order and the demand forecast of multiple products and the exponential smoothing technique. An illustration of five products further testifies the model, and it shows that the model facilitates to explore an optimal set of parameters to mitigate the bullwhip effect. [12] paper of studies relation of multi-terminals’ demand correlation and bullwhip effect in a two-stage supply chain with two retailers using the method under centralized or decentralized information. [10] In the paper simulated a simple three-stage supply chain using seasonal (SM) and deseasonalized (DSM) time series of the market demand data to identify, illustrate and discuss the impacts of different level constraints on the bullwhip effect is simulated.

Non-transparent information results in many parties in the supply chain conducting activities by predictions or inaccurate guesses. Retailers or shops often do not share sales information with distribution centers and factories. As a result, the factory only knows the demand pattern based on orders received from distribution centers. This information sharing can be done with centralized demand information (CDI), which is the concentration of demand information at each stage of the supply chain [18]. Centralized demand information is done by providing complete information on actual consumer demand at each level of the supply chain. Then by concentrating on that level of information, each level in the supply chain uses the actual data of the consumer's request to make the forecast more accurate and then becomes the forecasting result as a reference to determine the level of inventory and the number of requests or orders for the upstream stage. Reducing the bullwhip effect will reduce the total cost of inventory. This is evident from the research [19] dan [8]. The calculation bullwhip effect was based on centralized demand information (CDI), and also analysis cost of concentrate contribute material is done by [8]. This research has been done at Coca Cola Bottling Indonesia Central Sumatera Inc. The research used 83 types of product where distribution at two sales center. Research based on the previous centralized demand information method has also been carried out by [19]. The study was conducted on a cigarette distribution network that focused on two types of products. The scope of the research presented above shows that so many factors affect the bullwhip effect.

3. Methodology

This research is explorative research that discusses the bullwhip effect that happened on distribution process between manufacturer-distributor-retailers. Data collection is carried out by doing the observation on the case study organization. Same data that needed for conducting the research are the distribution network structure of supply chain, product demand data from retailers to distributor, product demand data from distributor from manufacturer, raw material and the price of product, lead time, the quantity of raw material for 12 periods (monthly), holding cost and set up cost. The object of the research is drinking water products in 240 ml cup, 380 ml bottles, 600 ml bottles, 1500 ml bottles, and 19 L gallons. Next step after data collection is done measuring the bullwhip effect that happened in the case study organization (without using Centralized Demand Information) and then obtain the total inventory cost of the material. The detail of the calculation as :

1. Measurement of the bullwhip effect
The first bullwhip effect measurement is to calculate the value of the initial bullwhip effect. Mathematically can be formulated as follows:

$$\frac{\text{Var}(Q)}{\text{Var}(D)} \geq 1 + \frac{2L}{p} + \frac{2L^2}{p^2}$$

When:

- \(p\) = period observation demand
- \(L\) = Lead Time

After this calculate of the initial bullwhip effect is done, then the bullwhip effect using Centralized Demand Information (CDI). For calculate bullwhip effect using CDI, this formula is used:

$$\frac{\text{Var}(Q)}{\text{Var}(D)} \geq 1 + \frac{2\sum_{i=1}^{k} L_i}{p} + \frac{2(\sum_{i=1}^{k} L_i)^2}{p^2}$$

When:

- \(p\) = period observation demand
- \(L\) = Lead Time
- \(k\) = level of parties involved in the distribution

The principle difference based on CDI is by concentrating product demand information by forecasting using actual data from the past. Demand forecasting is done using the WIN QSB 1.0 program application. The forecasting method used is adjusted to the data plot of each product. Forecasting results are determined from the forecasting method which has the smallest Mean Absolute Percentage Error (MAPE). Besides based on the smallest MAPE value, the forecasting results are also determined based on tracking signal testing. Signal tracking testing is a form of forecasting verification to see whether the forecasting function has represented the permanent system as a statistical control tool. This shows that the duration of the selected method is reliable. Furthermore, the measurement of the bullwhip effect is carried out on four levels of aggregation. After obtaining the results of the calculation of the initial bullwhip effect and based on the CDI, the values of both were compared, and the percentage of the decrease in the bullwhip effect was calculated.

2. Inventory cost of material is evaluated. The inventory cost of material is deciding by using Economic Order Quantity (EOQ) method. To deploy this method, the data such as raw material and the price of the product, lead time, the quantity of raw material, set up cost and holding cost is needed. The EOQ can be calculated using this formula:

$$Q^* = \sqrt{\frac{2DS}{H}}$$

$$TC = S \times \frac{D}{Q^*} = \frac{Q^*}{2} \times H + C$$

When:

- \(TC\) = Total cost inventory ($/year)
- \(Q^*\) = The optimum number of items on each order (EOQ)
- \(D\) (Demand) = Annual demand in units for supplies
- \(S\) (Setup) = Setup cost or order cost for each order
- \(H\) (holding) = Holding cost per unit / year
- \(C\) = Carrying cost ($/unit)
Moreover, the inventory cost at the condition and inventory cost resulted by using CDI are compared. And then, the impact of these bullwhip effect on the total inventory cost of the material is evaluated.

4. Result and Discussion

In this session, the result of calculating the initial bullwhip effect, bullwhip effect based on centralized demand information, and the inventory cost are explained.

a. Initial Bullwhip Effect

Based on the results of calculating the value of the initial bullwhip effect, a value is obtained which shows the magnitude of demand amplification in the supply chain network. The results for the order coefficient of variance with the sales coefficient of variance will show the results of the calculation of the bullwhip effect value. If the value of the bullwhip effect is annual or higher than 1.18 means that there is an amplification of demand for the product. Conversely, if the value of the bullwhip effect is lower than 1.18 means there is a smoothing of the demand pattern. The data aggregation process is carried out to determine the amount of variable in detail in the level of supply chain under study. Performed through 4 stages of data aggregation, namely product aggregation and retailers, products, retailers and echelon. Following are the results of measuring the bullwhip effect with four aggregation levels in Table 1.

| No | Calculation of the Bullwhip Effect                         | Initial Bullwhip Effect Value |
|----|-------------------------------------------------------------|-------------------------------|
| 1  | Level of aggregation of demand for products and retailers   | 1.579                         |
|    | $(\omega_1)$                                               |                               |
| 2  | Level of aggregation of demand for products $(\omega_2)$    | 1.465                         |
| 3  | Level of aggregation of requests for retailers $(\omega_3)$ | 1.162                         |
| 4  | The aggregation level of demand for echelon $(\omega_4)$    | 0.639                         |
|    | Average                                                    | 1.211                         |

The aggregation of demand for products and retailers is the most detailed analysis, where standard deviation and bullwhip effects are measured for the entire set of product requests for each retailer. The average calculation shows that some products experience a bullwhip effect. The passing value of the bullwhip effect shows how much the number of requests from retailers has increased the variable or amplified at the upper level, namely the distributor.

The aggregation of demand for products is done by grouping each product from each retailer. The number of requests for each similar product from each retailer has been grouped, so the demand becomes more stable. Where the bullwhip effect value for the aggregation level of this product tends to be smaller than the previous aggregation level. The aggregation of demand for retailers is a grouping of the number of requests for all products in each retailer.

Aggregation analysis of retailers is done to determine the variable demand for all products in the company and distributor. Grouping the number of product requests for each retailer causes a more stable amount of demand resulting in a smaller ratio of coefficient of variance. From the calculations performed, the bullwhip value is smaller than the previous aggregation level.

The aggregation measurement of demand for echelon where the overall demand data is summed for all products and retailers. From the results of calculations, the results of bullwhip values are getting smaller than the previous aggregation level. This shows the smoothing of demand patterns in the echelon.

Each supply chain actor tends to overestimate the number of requests. Exaggerate demand as a form of anticipation of meeting consumer needs. Every supply chain performer makes a self-request without coordinating. Actual consumer demand information is not accepted by parties in the upstream position. As a result, the manufacturer misreads the actual demand signal from consumers.
and retailers, resulting in inefficiencies in the supply chain network. Inaccurate information is, of course, detrimental to all parties involved in the supply chain network.

b. Bullwhip effect based on Centralized Demand information (CDI)

The calculation of the bullwhip effect value based on this centralized demand information (CDI) is carried out by centralizing the actual demand information upstream at each level of the supply chain. In accordance with the principle of central demand information, information centering is carried out by forecast the actual demand of retailers of the previous period. The bullwhip effect resulted from deploying (CDI) is also carried out with four levels of aggregation. The results of the value of the bullwhip effect based on CDI can be seen in Table 2.

Table 2. Value of bullwhip effect based on centralized demand information.

| No | Calculation of the Bullwhip Effect | Bullwhip Effect Value Based on CDI |
|----|-----------------------------------|-----------------------------------|
| 1  | Level of aggregation of demand for products and retailers (ω1) | 0.344 |
| 2  | Level of aggregation of demand for products (ω2) | 0.314 |
| 3  | Level of aggregation of requests for retailers (ω3) | 0.214 |
| 4  | The aggregation level of demand for echelon (ω4) | 0.082 |
|    | Average | 0.239 |

From the results of the calculation of the bullwhip effect value based on the concentration of information can be seen as a whole the level of aggregation experienced a decrease (smoothing) the value of the bullwhip effect. This shows that the demand forecasting data based on CDI meets the requirements to minimize the occurrence of the bullwhip effect because it is more accurate when compared to the prediction previously carried out.

c. Comparative Value of Bullwhip Effect

From the results of the comparison shows that there is a reduction in magnitude bullwhip effect after using the CDI method. The results are shown in Table 3.

Table 3. The percentage of decreasing of bullwhip effect.

| No | Calculation of the Bullwhip Effect | Initial Bullwhip Effect Value | Bullwhip Effect Value Based on CDI | Decrease | Percentage Decrease |
|----|-----------------------------------|-----------------------------|-----------------------------------|----------|---------------------|
| 1  | Level of aggregation of demand for products and retailers (ω1) | 1.579 | 0.344 | 1.235 | 78.20 % |
|    | Level of aggregation of demand for products (ω2) | 1.465 | 0.3142 | 1.151 | 78.55 % |
|    | Level of aggregation of requests for retailers (ω3) | 1.162 | 0.214 | 0.948 | 81.57% |
|    | The aggregation level of demand for echelon (ω4) | 0.639 | 0.082 | 0.557 | 87.12% |

From the results, it showed that the bullwhip effect based on CDI is decreased for of levels. This shows that the forecasting result meets the requirements to minimize the occurrence of the bullwhip effect. The forecasting results are more accurate when compared to the previous forecast.
d. Initial Inventory Cost

In making optimal order lot measurements, each material using the Economic Order Quantity (EOQ) method is influenced by several variables is the amount of material required is obtained from the number of needs and ordering of each material carried out by PT. X to each supplier. The cost of this message includes transportation costs. Administrative and telecommunications costs and the cost of loading and unloading. The cost of saving is the cost incurred by the company to store material. This cost is assumed to be 10% of material costs. The total cost is the sum of the purchase costs, the cost of the holding and the cost of the store for a year. In table 4 show the total initial inventory cost. Table 4 shows the total details of 2017 material supply costs.

Table 4. Total initial inventory costs.

| No | Material name [2] | Unit Unit | Amount of Purchase /year [3] | Price per unit [4] | Save / unit costs [5] | Holding cost [6] | Ordering Lot Size (unit) [7] | Annual Purchase cost (Rp.) [8] = [3] [4] | Set Up Cost Per Year (Rp.) [9] = [6] x [7] / [7] | Annual Save cost (Rp.) [10] = 1/2 [9] [5] [4] | Total Cost Per Year (Rp.) [11] = [8] + [9] + [10] |
|----|-------------------|-----------|-----------------------------|-------------------|--------------------|----------------|-------------------------|---------------------------------|---------------------------------|---------------------------------|--------------------------------|
| 1  | Propylene trilene popy resin | Gram      | 306,000                     | 22,000            | 0.1                | 19,250,000     | 23,900                   | 6,732,000,000                   | 246,463,202                     | 26,290,132                      | 7,004,75,333                    |
| 2  | Cover Lid         | Roll      | 3,350                       | 1,148,000         | 0.1                | 4,780,000      | 108,422                  | 129,200,000                   | 5,466,529                       | 11,250,000                      | 3,906,67,307                    |
| 3  | Preform 380 Preform 600 | Pcs       | 380,000                     | 380,000           | 0.1                | 3,770,000      | 234,482                  | 129,200,000                   | 5,466,529                       | 11,250,000                      | 139,121,678                    |
| 4  | Preform 1500      | Pcs       | 380,000                     | 440,000           | 0.1                | 4,270,000      | 248,409                  | 167,200,000                   | 6,531,981                       | 11,250,000                      | 179,196,969                    |
| 5  | Label 380         | Pcs       | 270,000                     | 680,000           | 0.1                | 3,020,000      | 135,806                  | 183,600,000                   | 6,004,135                       | 11,250,000                      | 194,211,533                    |
| 6  | Label 600         | Pcs       | 858,000                     | 250,000           | 0.1                | 1,370,000      | 214,850                  | 214,500,000                   | 5,471,080                       | 26,290,000                      | 222,656,702                    |
| 7  | Label 1500 240 carton 380 cardboard 1500 cardboard 600 HDPPPE | Pcs | 380,000                     | 300,000           | 0.1                | 1,370,000      | 41,275                   | 11,400,000                   | 1,261,281                       | 619,132                         | 127,231,942                    |
| 8  | Label 1500 240 cardon 380 cardboard 1500 cardboard 600 HDPPPE | Pcs | 135,000                     | 325,000           | 0.1                | 797,000        | 28,751                   | 43,875,000                   | 3,742,315                       | 467,202                         | 48,084,518                     |
| 9  | Preform 1500      | Pcs       | 14,250                      | 3,500             | 0.1                | 6,150,000      | 258,519                  | 7,507,500,000                 | 51,028,165                      | 45,240,824                      | 7,630,76,989                   |
| 10 | Preform 1500      | Pcs       | 15,750                      | 3,700             | 0.1                | 2,325,000      | 11,771                   | 58,275,000                   | 3,110,918                       | 2,177,643                       | 63,563,61                    |
| 11 | Preform 1500      | Pcs       | 11,250                      | 3,800             | 0.1                | 2,325,000      | 9,817                    | 42,750,000                   | 2,664,499                       | 1,865,149                       | 47,279,48                     |
| 12 | Preform 1500      | Pcs       | 850,000                     | 65,000            | 0.1                | 3,270,000      | 820,249                  | 55,250,000                   | 3,388,607                       | 2,665,808                       | 61,304,415                    |
| 13 | Gallon            | Pcs       | 16,000                      | 38,000            | 0.1                | 1,100,000      | 1,841                   | 608,000,000                  | 9,559,750                       | 3,497,999                       | 621,057,749                   |
| 14 | Close Gallon      | Pcs       | 600,000                     | 100,000           | 0.1                | 3,250,000      | 3,523,393                | 60,000,000                   | 2,767,219                       | 167,296,12                      | 66,290,612                    |
| 15 | Tissue            | Pcs       | 600,000                     | 50,000            | 0.1                | 775,000        | 136,382                  | 30,000,000                   | 3,409,545                       | 340,955                         | 33,750,500                    |
| 16 | Raw water         | Cubic     | 26,500                      | 1,500,000         | 0.1                | 1,500,000      | 1,438                   | 120,000,000                  | 27,642,559                      | 27,653,818                      | 20,550,514                    |
|    | TOTAL             |           |                             |                   |                    |                |                         | 19,860,650,000               | 855,372,202                    | 160,897,944                    | 20,590,514                    |

e. Total Cost of Inventory After CDI

From the calculation of total inventory costs after using the CDI, there is a decrease in total costs. Calculation of total costs using the EOQ principle can be seen in table 5.
f. Percentage of Decrease in Total Inventory Cost

Calculation of total inventory costs before using the CDI and after using the CDI the difference is quite significant. In table 6 below can be seen the percentage of inventory costs that occur.

Table 5. Total cost of inventory after CDI.

| No. | Material | Amount of Material Requirement Per Year (Unit) | Material prices per unit (Rp) | Message Fee (Rp) | Size of Order Lot (Unit) | Annual Purchase Costs (Rp) | Annual Message Costs (Rp) | Annual Save Costs (Rp) | Annual Total Cost (Rp) |
|-----|----------|---------------------------------------------|-----------------------------|-----------------|--------------------------|---------------------------|--------------------------|------------------------|------------------------|
| 1   | Propylene trilene popy resin pp trilene he 2.o | 281,201                      | 22,000                     | 0.1             | 570,500                  | 12,076                    | 6,186,419                 | 13,284                 | 12,382                 |
| 2   | Cup Lid Lid | 93,733,636                    | 28                          | 0.1             | 4,090,500                | 16,549,006                | 2,624,541                 | 23,168                 | 23,168                 |
| 3   | Pre form 340 | 218,304                      | 380                         | 0.1             | 3,072,500                | 187,888                   | 82,955,520                | 3,569                  | 3,569                  |
| 4   | Pre form 600 | 173,554                      | 440                         | 0.1             | 3,572,500                | 72,837                    | 76,363,860                | 8,512                  | 9                     |
| 5   | Pre form 1500 | 65,232                       | 680                         | 0.1             | 2,322,500                | 39,104                    | 44,357,760                | 3,874                  | 8                     |
| 6   | Label 380 | 218,304                      | 250                         | 0.1             | 672,500                  | 108,373                   | 54,576,000                | 1,354                  | 5                     |
| 7   | Label 600 | 173,554                      | 300                         | 0.1             | 672,500                  | 88,210                    | 52,066,268                | 1,323                  | 15                    |
| 8   | Label 1500 | 65,232                       | 325                         | 0.1             | 99,500                   | 19,986                    | 21,200,400                | 1,323                  | 15                    |
| 9   | 240 Carton | 1,952,784                    | 3,500                       | 0.1             | 5,452,500                | 246,664                   | 6,834,744                 | 43,166                 | 15                    |
| 10  | 380 carton | 9,096                        | 3,600                       | 0.1             | 1,627,500                | 9,096                     | 32,745,600                | 1,632                  | 15                    |
| 11  | 600 cardboard | 7,231                       | 3,700                       | 0.1             | 1,627,500                | 7,976                     | 26,756,277                | 1,475                  | 5                     |
| 12  | 1500 cardboard | 5,436                     | 3,800                       | 0.1             | 1,627,500                | 6,824                     | 20,656,800                | 1,296                  | 1                     |
| 13  | HDPE   | 457,090                      | 65                          | 0.1             | 2,572,500                | 601,502                   | 29,710,865                | 1,954                  | 1                       |
| 14  | Gallon  | 3,686                        | 38,000                      | 0.1             | 402,500                  | 884                       | 140,078,368               | 1,679                  | 1                       |
| 15  | Close the gallon | 3,686                   | 100                         | 0.1             | 2,552,500                | 43,380                    | 368,627                  | 216,901                | 123                    |
| 16  | Tissue  | 3,686                        | 50                          | 0.1             | 77,500                   | 10,690                    | 184,314                  | 26,725                 | 26,725                 |
| 17  | Raw water | 22,851                       | -                           | 0.1             | 1,500,000                | 1,335                     | 120,000,000               | 25,674                 | 93                     |
|     | Total   |                              |                             |                 |                          |                           |                           | 16,603                 | 340.579               |

Table 6. Percentage of decrease in prepaid total cost.

| Cost component | Initial Inventory System (Rp) | Inventory System After CDI (Rp) | Inventory Cost Difference (Rp) | Percentage Decrease |
|----------------|-------------------------------|---------------------------------|--------------------------------|---------------------|
| Purchase Costs | 19,963,250,000               | 16,347,726,708                 | 3,615,523,292                 | 18.11%              |
| Storage Costs  | 160,897,944                  | 132,534,355                    | 28,363,589                    | 17.63%              |
| Booking Fee    | 855,372,202                  | 123,079,516                    | 723,292,686                   | 85.61%              |
| Total Inventory Cost | 20,550,514,234    | 16,603,340,579                 | 3,947,173,655                 | 19.21%              |

From the recapitulation of the difference in total inventory costs in table 6, it proves that the use of centralized demand information that affects the decline in the bullwhip effect will also affect the decrease in inventory costs. Where the cost of purchasing each original material is higher than the purchase cost based on the CDI. The difference in purchase costs incurred is 18, 11%. This is due to the calculation of the cost of purchasing with the initial material with the amount of material required is an estimate from the distributor without knowing exactly how much the actual needs needed by the
retailer. While based on the CDI obtained from the needs of the actual demand forecasters retailers to distributors. So that the forecasting results are more accurate and following the actual number of retailer's requests.

The cost of storing the inventory system after the decline in the bullwhip effect based on the CDI also decreased by 17, 63 %. This happens because the amount of inventory from the calculation of the needs of each material for a decrease in the bullwhip effect based on the CDI becomes more optimal. In addition to a decrease in storage costs, there was also a significant decrease in the cost of messages, 85.61 %. The third element of the fee will know the total cost of inventory after using CDI experienced a considerable reduction of the total cost of the initial inventory is 19, 21%. This has a positive impact on the company, in addition to indirectly reducing the bullwhip effect on the distribution network in the company, it is also able to reduce material inventory costs at PT. X

5. Conclusion

The Bullwhip effect is a phenomenon observed in distribution channels that form a supply pattern that is not following the actual pattern of consumer demand. From the results of research conducted on the distribution network of PT X, there was a bullwhip effect. From the results of the calculations that have been done, it can be concluded that the higher the level in the supply chain, the higher the value of the bullwhip effect. This is caused by the number of products manufactured by manufacturing is higher than sales by marketing. So it is necessary for each party to build a transparent, accurate and integrated information system regarding matters relating to product demand and availability that can be done through information sharing. This can reduce the occurrence of forecast errors or the estimated number of requests that do not mix across the supply chain lines so that it will affect the decline in the bullwhip effect. The use of the principle of centralized demand information further enhances the decline in the bullwhip effect pattern. The inventory system after reducing the bullwhip effect can provide savings in the total annual inventory costs for the company.

6. References

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