

Analysis of bullwhip effect on supply chain with Q model using Hadley-Within approach

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Abstract. This research held on a tapioca flour industry company that uses cassava as raw material to produce tapioca starch product. Problems that occur in this company is inaccurate planning, consequently there is a shortage of variation between the number of requests with the total supply is met, so it is necessary to do research with the formulation of the problem that is how to analyze the Bullwhip Effect on the supply chain using Q model through Hadley-Within approach so as not to disturb the product distribution system at the company. Product distribution system at the company, obtained by the number of requests. The 2015 forecast result is lower than actual demand for distributors and manufactures in 2016 with average percentage difference for Supermarket A distributor, Supermarket B and manufacturing respectively 38.24%, 89.57% and 43.11% . The occurrence of information distortion to the demand of this product can identify the existence of bullwhip effect on the supply chain. The proposed improvement to overcome the bullwhip effect is by doing inventory control policy with Q model using Hadley-Within approach.

1. Introduction

Lean manufacturing concept is widely applied in the world, some of the previous studies that discussed lean manufacturing as in lean improvement research were then simulated and investigated before being implemented, allowing systematic design of slim improvement [1]. Lean manufacturing is also used for maintenance management, which is the implementation of maintenance management and lean manufacturing techniques in maintenance workshops to eliminate losses due to damage and to improve productivity and employee motivation in companies that produce dairy products [2]. In addition, this study also discusses the supply chain, as previous research which states that the merger of the bullwhip effect method with supply chain [3]. And other research mentioned about forecasting supply chain, almost same with the method applied in this research [4] [5]. In lean manufacturing practices such as manufacturing processes and equipment, manufacturing planning and scheduling, visual Information systems, supplier relationships, customer relations, labour and product development & technology [6]. Some even combine kanban method with lean manufacturing [7]. In addition there is also a combination degan fuzzy method [8]. This research combines three methods namely kanban, supply chain and lean manufacturing.

This company is a company that processing sweet potato into tapioca flour as the finished product. The marketing area of tapioca flour products of this company is generally in Sumatera area and more focused in Medan area and developed to the area of Aceh, Padang, Jambi, Pekanbaru, and Palembang.



The company must be able to plan and control the finished product inventory appropriately to meet the demand and stock of the company's products.

Output product is the most produced products by the company compared to other types of flour products. And the production is make to stock so that it can cause the accumulation of products (over stock) or product shortage (stock out) if the planning is not accurate. Production data of flour products in 2015 can be seen in table 1.

Table 1. Demand and Sales Data Year 2015 (boxes)

Month	Demand (Distributor)	Sales (Manufacture)	Variance Value
January	2602	2551	51
February	2720	2510	210
March	2512	2413	99
April	2548	2443	105
May	2790	2495	295
June	2606	2432	174
July	2667	2475	192
August	2446	2463	17
September	2850	2464	386
Oktober	2669	2543	126
November	2555	2424	131
Desember	2458	2389	69
Total	31423	29602	1821

Table 1 above shows the variance values between the number of requests and the number of sales that resulted in stock outs during the 2015 period of 1821 boxes which could not be met. In August 2015 there was a stockpiling of inventory (over stock). Overstock and stock outs are caused by demand that is likely to change. The change causes a demand distortion. This distortion leads to inaccurate demand, so there is a varied difference between the number of requests and the number of sales. This phenomenon is called the bullwhip effect. In handling probabilistic phenomena taken with the Q model because it is responsive in case of lack of goods compared with other models. In addition, the amount of safety reserves is more accurate because it is set simultaneously with cost optimization. Q model inventory policy with Haldey-Within approach.

2. Research Method

The object of this research is distributor of Lotte Mart and distributor of Berastagi Supermarket with observed data that is product demand data. The selection of distributors due to the area of distributor marketing is very broad, in addition to these distributors also have large retailers so that the number of requests received by the company is also very large.

The methodology used to collect data is as follows:

1. Conduct direct observation of the object of research.
2. Utilizing historical data
3. Library study from various sources

Then do the data processing obtained from the data collection in the company. Data processing using inventory control policy with model Q using Hadley-Within approach, so obtained by economical lot order size (qo) and security reserve (ss) optimal.

3. Result and Discussion

3.1. Bullwhip Effect Analysis

The size of the bullwhip effect in a supply chain echelon is the ratio between the variance coefficient of demand (C_{out}) and the coefficient of sales variance (C_{in}).

Systematically can be written:

$$\omega = \frac{C_{out}}{C_{in}} \quad (1)$$

$$C_{out} = \frac{\sigma[D_{out}(t,t+T)]}{\mu[D_{out}(t,t+T)]} \quad (2)$$

$$C_{in} = \frac{\sigma[D_{in}(t,t+T)]}{\mu[D_{in}(t,t+T)]} \quad (3)$$

where, σ = demand standard deviation

μ = average demand

t = t time interval

T = horizontal demand t time interval

$D_{out}(t,t+T)$ and $D_{in}(t,t+T)$ are the request over a time interval $(t, t + T)$ and will be written as D_{out} and D_{in} . Based on the result of identification of bullwhip effect, bullwhip effect value is less than one on Lotte Mart distributor (0,1982), Berastagi Supermarket (0,2425), and also its manufacture (0,2382). The value of the bullwhip effect is less than one, meaning there is no demand variability in Lotte Mart's distributor supply chain, and distributor Berastagi Supermarket, as well as its manufacturing supply chain. However, the value of the bullwhip effect that is smaller than one indicates an increase in the variability of sales of Gunung Agung products.

Based on the identification of bullwhip effect, it is known that the cause of bullwhip effect is:

1. Demand Forecasting Updating

The inaccuracy of demand made by the manufacture resulted in the variability of demand in the supply chain.

2. Lot Sizing

Lot Sizing is necessary because the production process and product delivery will not be economical if done in small size. A relatively stable end-of-day customer request will turn into a weekly or biweekly order from a retailer so that the distribution centre will receive a more volatile order than the demand faced by the retailer.

3. Rationing and Shortage Gaming

Distributors and retailers often do rationing, when the demand is often not entirely fulfilled in full, the result is often when the inventory is sufficient, the distributor and retailer change or cancel their order it will damage the market information on the supply chain.

4. Price Fluctuation

Promotional policies in the form of discounting lead to changes in demand. Demand jumps at the time of discounting and decreases when the discount diverges.

The delay in order completion occurs repeatedly with a small number of delays as shown in table 1.

3.2. Inventory Policy with Q model

The inventory policy with the Q model using the Haldey-Within method has an advantage in the determination of the optimal lot size and the safeguard reserves are easily solved analytically because the solution search is done iteratively. Comparison of inventory calculation includes optimal inventory policy and total inventory cost for Lotte Mart, Berastagi Super Market, and its manufacturing chain can be seen in tables 2 – 4.

Table 2. Calculation of Inventory Control of Lotte Mart Distributor in 2016

Inventory control	Notation	Lotte Mart
Average demand	D	1675
Lack of inventory	N	1
Order lot size	q_o^*	24
Safety Stock	Ss	6
Reorder point	r^*	1
Level of service	η	98 %
Total inventory cost	Ot	Rp 84,856,875

Table 3. Calculation of Inventory Control of Distributor Berastagi Supermarket in 2016

Inventory control	Notation	Brastagi
Average demand	D	1158
Lack of inventory	N	1
Order lot size	q_o^*	20
Safety Stock	Ss	3
Reorder point	r^*	6
Level of service	η	98 %
Total inventory cost	Ot	Rp 58,877,025

Table 4. Calculation of Manufacturing Inventory Control In 2016

Inventory control	Notation	Manufacturing
Average demand	D	2834
Lack of inventory	N	1
Order lot size	q_o^*	31
Safety Stock	Ss	9
Reorder point	r^*	16
Level of service	η	99 %
Total inventory cost	Ot	Rp 143,134,642

Several approaches can be proposed to overcome the bullwhip effect i.e.:

1. Information Sharing

Sharing demand information to all subjects in the supply chain, including distribution centres, factories, or suppliers of components or raw materials. Forecast errors across supply chain lines can be reduced by better exchange of information. Improved management and forecasting techniques

2. Improved Demand Management / Forecasting can be done by improving the techniques of forecasting, especially in the manufacturing sector to obtain more accurate demand forecasting results.

3. Creating stable price.

To avoid a forward buying reaction, the frequency and intensity of partial promotional activities like this should be reduced and more directed to continuous price reductions so as to create

programs such as everyday low price. Or even if promotional activities or price reductions are made, all parties to the supply chain must know the program well so that it is not mistaken in estimating the real demand.

4. Reduction of fixed costs

For procurement sector, lot size of orders can be reduced by eliminating excessive administrative activities by eliminating activities that do not provide added value such as optimization.

Company data show that the largest number of delays occurred in Main Shaft products with a delay in August of 24 units, September at 12 units and in October 40 units.

4. Conclusion

Based on the analysis of processing and discussion of data, it can be taken some conclusions, namely:

1. Based on forecasting results in 2015 lower than actual demand on distributors and manufactures in 2016 with average percentage of difference for distributors Lotte Mart, Berastagi Supermarket, and manufacturing respectively by 38.24%, 89.57%, and 43.11%.
2. The result of forecasting comparison of bullwhip effect value of demand in 2015 with actual demand for 2016 for distributor of Lotte Mart, Berastagi Supermarket and at its manufacturing chain is 0,1982; 0.2425, and 0.2382.
3. Proposed Solution to overcome the bullwhip effect at PT. Florindo Makmur is by reducing the bullwhip effect by paying attention to the needs and safety supply using the Q model through the Hadley-within approach, then determining the economical lot order size, the safety reserves and the total inventory expectations.

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