AGRARIS: *Journal of Agribusiness and Rural Development Research*

Vol. 7 No. 1 January-June 2021,
Pages: 1-10

*Article History:*
Submitted: September 17th, 2020
Accepted: November 12th, 2020

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# Bullwhip Effect Study in Leaf Organic Supply Chain

DOI: https://doi.org/10.18196/agraris.v7i1.9842

## ABSTRACT

The mismatch between the availability of vegetables and consumer demand was one of the causes of inefficient supply chains. This study aims to analyze the bullwhip effect on the organic leaf vegetable supply chain at PT. Simply Fresh Organic (SFO). The analysis method used was a comparison between the coefficients of variation of orders created with the coefficient of variation in requests received by each supply chain institution. The data used were secondary data obtained from PT. SFO. The measurement results show that the supply chain flow of organic leaf vegetables had a bullwhip effect at the PT. SFO level and no bullwhip effect occurs at the retail level. The value of the BE supply chain value calculation at PT. SFO shows a higher figure than at the retail level. The bullwhip effect at PT. SFO occurred because of a rationing and shortage gaming policy. Therefore, each member of the supply chain must maintain transparency of data information and utilize digital technology to improve the accuracy of data forecasting requests and reservations quickly.

**Keywords**: Bullwhip Effect, Rationing, and Shortage Gaming

## INTRODUCTION

The raising of vegetable production in Indonesia had large potential. It is supported by the increase of vegetable field area from 1,033,817 Ha in 2012 to 5,678,554 Ha in 2016 (BPS, 2017a). That increase surely had a positive impact on the amount of vegetable crop production. In 2012, the amount of vegetable crop production in Indonesia attains 10,762,704 tons, and it is to get higher became 15,682,656 tons in 2016. Because of that, the vegetable stock in the market is going overflow and make it easier to reach for the consumer. From the data of vegetable consumption per capita per year, it can be seen the consumer ability. According to the data from 2010-2016, there was an increase in the consumption rate of fresh vegetables in Indonesia as much as 27.04 Kg/capita per year (BPS, 2017b). It is shown that consumption-ability per capita corresponded with field area increase, amount of production, and vegetable stock in the market.

As quick as information transfer about organic vegetables in Indonesia, most Indonesian started to consume organic vegetables. Most of them are from South Jakarta. (Aufanada *et al.*, 2017). Besides, the educational background became a factor for the consumer to choose organic vegetables. It is mean that a higher education background,

a higher probability for a consumer to choose organic vegetables for consumption (Devi *et al.*, 2015). Since education predisposed how a person thinks both directly or not, then make an impact on decision-making. For example, a society who have high educational background tended to healthy live orientation with organic vegetable consumption. According to Aliansi Organic Indonesia's data in 2017, the amount of Organic consumer increased 1% compared to the last year (AOI, 2017). Except the good taste from organic vegetable, health advantage become the rationale from consumer (Silitonga, 2014).

West Java is crowned to be the most food producer that use organic methods in Indonesia that is 34 in total (AOI, 2011). Besides, all of them had certified from a credible national of Organic Farming Certification; in Indonesia called *Lembaga Sertifikasi Organik* (LSO). Then, one of them called *Kelompok Tani Mandiri* (Dependent Farmer Group) which was certified from LSO Inofice (Indonesian Organic Farming Certification). All of their crops are supplied to PT. Simply Fresh Organic (a company retail). PT. SFO is a company that motto "Fresh from Field to Table" and bridge the farmer to various retail in Jabodetabek area that made cooperation with PT. SFO company. PT. SFO had 62 variances organic vegetables which have been certified, and one of the most superior products is horenso (Japanese Spinach). Horenso belonging to a kind of spinach that had the most shipping among the other company's vegetable products. That amount can be seen in figure 1 below:

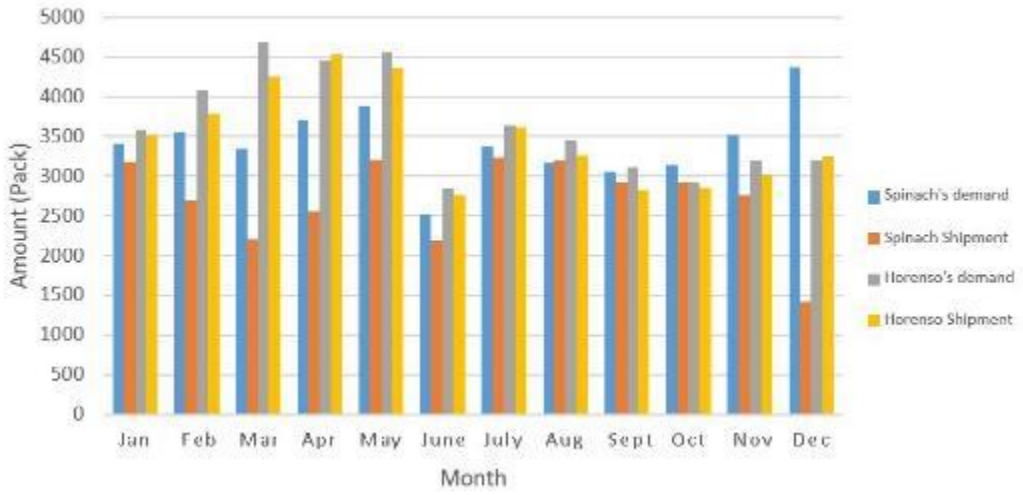


**FIGURE 1. AMOUNT OF ORDER AND SHIPPING OF LEAF VEGETABLES IN PT. SFO IN 2017**

Figure 1 shown that amount of order and shipping in 2017 was always fluctuating. Order and shipping activity had an opportunity to increase in April and Mei, yet get a decrease in June. It happened since June was concurrent with fasting month and Eid Mubarok, so there were some long holidays and no shipping activity. The amount of leaf vegetable shipment, both horenso and spinach, always get smaller than the order value given by retail. Whereas the company had ordered to the farmer due to the needs, even more, exaggerated to anticipate vegetable breakage during the shipping. Farmer not surely can comply with the demand optimally. Meanwhile, the stock is an important key that had to get

the attention of the vegetable supply chain (Marimin & Hadiguna, 2007). Christopher (2011) clarified that the supply chain is an organization network that made interaction in every different activity from the upstream to the downstream that can make value aimed at the last consumer.

Leafy vegetables that are prone to damage and rotten make supply chain executant had to be more careful with leaf vegetable handling. Moreover, if those left in outdoor temperature, those will be rotten in an hour. Likewise, spinach is easier to rotten if not saved in a refrigerator because its stem had lots of water. That characteristic make supply chain executant hard to determine how many vegetables must be prepared. Besides, the unpredictable demand and stock should be minimized to prevent loss of offers. That fluctuating condition plus difficulties to ensure leaf vegetable stock resulted in adversity in demand forecasting in the company. Eventually, that will make the bullwhip effect phenomenon and inexpediency of vegetable stock with consumer demand. The bullwhip effect is considered to be the main cause of the inefficiency of the supply chain, whereas the success of a company related to supply chain efficiency (Tarasewicz, 2016).

Similar to previous research in PT. Lotte Chemical Titan Nusantara, a company that produced Polyethylene (PE), shown a result that the main cause of the Bullwhip Effect is price fluctuation and rationing and shortage gaming. Price fluctuation in global caused unstable order amount and Demand Company. Besides, the cause that must be suspected is forecasting activity performed on sales target, because the company cannot be ready with the amount of stock if it just focusing on the target (Sari *et al.*, 2013). Technically, the bullwhip effect phenomenon will have appeared if there is no effective booking system in the company (Lestari *et al.*, 2017).

The determination of how much vegetable amount will be ordered will affect total cost in any supply chain network unit. Data shown the suppliers were not counting the exact number of order. That happened since suppliers assumed that all consumer order fulfillment will reduce the supply chain cost. This assumption is often not realized and lead to the supplier to make mistake in order forecasting. In the other research resulted, the total cost is linear with the total amount of booking goods. Besides, it is important to know that the information of the total amount of order must be centered and be discovered by all of supply chain network because the number of ordered goods in consumer-level do not represent consumer needs in real-time. Ordered variation in consumer-level had covered safety stock (Lestari *et al.*, 2017).

The other bullwhip effect research had been conducted previously on horticulture commodities in Lottemart Bogor which is grape, onion, big chili, and import carrot. Some factors that lead to the bullwhip effect on that commodities are price fluctuating, irregular order grouping, and updating of demand forecasting is done by many supply chain executants (Tsaqiela *et al.*, 2016). The novelty from previous research is the bullwhip effect measured in two supply chain levels, the first one is the company level and the second one at the retail level. That result aimed to determine as well as compare any condition upstream and downstream, because the bullwhip effect phenomenon did not always happen in every supply chain level.

Some scientists regarded that demand forecasting methods can reduce the bullwhip effect (Alwan *et al.*, 2003 and Hayya *et al.*, 2006). Another bullwhip effect research in Locarvest Bandung aimed to observe the most effective forecasting methods for determining the amount stock of vegetables before shipping on the modern market. Largest agreed on a swap-trade system with the condition that the cost for goods which are not sold will be borne by Locarvest and replaced on the next day. However, this agreement turned out to be detrimental to Locarvest because too many vegetables were not sold and damage. Therefore, locarvest must determine the right forecasting methods in order to minimized product return (Samangi & Perdana, 2018). This trading system is used by Locarvest and PT. SFO is better known as a consignment. Trade of a consignment is an agreement between the product owner and seller to help to sell the product for getting some commission as a benefit (Apriyani *et al.*, 2018).

In contrast to previous research, this research aimed to find the right strategy for the minimized bullwhip effect. The bullwhip effect phenomenon showed that variabilities tended to rise from the customer supply chain to the supplier (Talitha, 2010). This mean, the number of order to farmers is much higher and fluctuate in upstream level (PT. SFO). However, the number of order in retail is much more stable. From that case, it is important to evaluate the bullwhip effect to formulate the best solution to optimize the benefit. This effort engaged all of the supply chain levels, so that will affect any chain activity, as well as profits. Therefore, this research aimed to analyze the bullwhip effect phenomenon along the supply chain of vegetable and organic leaf in PT. SFO.

## RESEARCH METHOD

PT. SFO was chosen as a subject in this study since this company was the first organic food company in the Cipanas subdistrict and contributed to reducing unemployment around. Also, PT. SFO was bridging sales for any kind of vegetables to the modern market. This selection used purposive sampling with a case study approach.

Order and demand data in every supply chain agency were using as secondary data in this study. Those data, which was a literature review, were obtained from the company archive during a year. Both data had a daily period with two chosen commodities as well as spinach and horenso. Those commodities are chosen with purposive sampling since have the highest shipping total than others.

The occurrence of the bullwhip effect phenomenon can be identified by calculating two components namely coefficient of variation out of the amount of order and coefficient of variation from demand total appeared in related level (Pujawan & Mahendrawathi, 2017). Bullwhip effect measurements are performed in every echelon and every product within it. Its value calculation will engage the coefficient of variation value showed homogeneity of demand data distribution, and supply chain executant order of organic leaf vegetable during 2017. The smaller coefficient value, the more homogeneity its data distribution and vice versa. Mathematically as follows:

$$BE = \frac{CV\ (Order)}{CV\ (Demand)} \quad (1)$$

where: $$CV\ (order) = \frac{S(Order)}{Mu\ (Order)} \quad (2)$$

$$CV\ (demand) = \frac{S\ (Demand)}{Mu\ (Demand)} \quad (3)$$

While the parameter for the bullwhip effect as follows:

$$\frac{CV\ (Order)}{CV\ (Demand)} > 1 + \frac{2L}{P} + \frac{2L^2}{P^2} \quad (4)$$

Where, CV (Order) was Coefisien Var. Sales, CV (Demand) was Coefisien Var. Demand, S(Order) was sales deviation standard, Mu (Order) was average of sales (pak), S (Demand) was demand deviation standard, Mu (Demand) was average of demand (pak), L was Lead Time order accomplishment, P was observe period (day).

Bullwhip effect parameter was a result calculated from a constant value which summed up with a comparison of order accomplishment lead time and observation period. That parameter in a supply chain can be different on other chains because its value was affected by lead time duration and observation period. Some criteria used as parameter reference were; if BE scores bigger than parameter score then there will be bullwhip effect phenomenon. However, if BE scores smaller than the parameter score, the bullwhip effect will not appear.

## RESULT AND DISCUSSIONS

One must-be-noticed element in the supply chain is the information flow, except money and goods, in every activity. That is because, the more supply chain network, the more complex information need to be managed (Jakfar *et al.*, 2015). Information distortion, since slow information delivery, affected order and product demand mismatch of company. That information distortion even can be understood as an important factor that triggered the bullwhip effect phenomenon (Susilo, 2008). Since information distortion affected inaccuracy of company decision to manage consumer demand (Perdana, 2015). Bullwhip effect can appear from a fault of the forecasting process in supply chain institute. Bullwhip effect analysis was performed in order to find out the order and demand variability level of leaf organic vegetables in every commodity in every supply chain institute and echelon. The result can be seen in Table 1.

Table 1 showed that the bullwhip effect average score in every supply chain in PT. SFO had a bullwhip effect. It can be seen from the BE score that bigger than its parameter. BE score of spinach commodities was 1.6897 or bigger than 1.0065 as parameter score then bullwhip effect appeared in the supply chain of spinach. Likewise horenso commodities, the bullwhip effect average score was 1.4324 or bigger than its parameter. Therefore, it can be concluded that the bullwhip effect appeared in the supply chain of leaf organic vegetables in PT. SFO level. Bullwhip effect phenomenon was marked using a coefficient score of order

variation that bigger than consumer demand coefficient variation so order data's spread tend to be more heterogeneous than accepted demand data.

**TABLE 1. BULLWHIP EFFECT SCORE OF LEAF ORGANIC VEGETABLE IN PT. SFO**

| Explanation | Vegetable Types | | | |
|---|---|---|---|---|
| | Spinach | | Horenso | |
| Variable | Order | Demand | Order | Demand |
| Total | 44,317 | 55,847 | 40,156 | 43,768 |
| Average | 138.92 | 186.16 | 126.68 | 148.37 |
| STDV | 68.5 | 53.24 | 67.22 | 55.51 |
| CV | 0.49 | 0.29 | 0.53 | 0.37 |
| BE score | **1.6897** | | **1.4324** | |
| Parameter | 1.0065 | | 1.0065 | |
| Result | FALSE | | FALSE | |

There were so many factors that caused the inefficiency of the supply chain activity of leaf organic vegetables and triggered the bullwhip effect phenomenon. It can be expected that bullwhip effect appearance since decision-making which is rationing and shortage gaming (Apriyani *et al.*, 2018). This decision-making was taken when leaf organic vegetable was higher than its company stock. This condition had been anticipated by exaggerating the number of order to the farmer, but sometimes still missed (error forecasting) because it depends on the season and the weather (which is hard to predict). When leaf organic vegetable demand was higher than the stock provided by the company, PT. SFO will only fulfill a portion of the number of costumer only. Later, since the customer know that half of its order that had fulfilled, retail increased the number of demand with the expectation that if using rationing they still got enough shipment. Yet the company stock is enough to fulfill all of the orders, retail canceled, or reduce the order.

The error forecasting event that caused missed approximation was suspected since there was inaccurate base data used by the company, because of PT. SFO still used manually flow-movement records not computerized yet. Bullwhip effect in PT.SFO cannot be avoided since the number of shipping was performed by forecasting events. Based on that case, it can be said that the bullwhip effect happened is a price to pay for unstable demand forecasting activity and an effort to detect what trend is happening at the consumer level (Dejonckheere *et al.*, 2003).

Rationing and shortage gaming factors or demand forecasting based on sales targets is causing a bullwhip effect on the supply chain system in PT. Lotte Chemical Titan Nusantara especially on Polyethylene (PE) product. The improving strategy performed by PT. Lotte Chemical Titan Nusantara is reducing bullwhip effect score in any echelon using discrete simulation on Microsoft Excel. Reducing the bullwhip effect score is expected to stabilize the price in the market, then every echelon obtained fair profit (Sari *et al.*, 2013).

This study measured order and demand score at the retail level, as well as company level, to see the bullwhip effect possibilities on the next chain. The next bullwhip effect measurement was performed in every leaf organic vegetable supply chain of four partners retails of PT.SFO such as Top Cibubur, Total Buah Thamrin, Duta Buah, and Allfresh

Gatot Subroto. Retail is the nearest supply chain institute with the last consumer Based on that fact, retail should more be aware of the characteristics and dynamics demand data of consumers more detailed than the institute in the upstream level because leaf organic vegetable demand in the retail (downstream level) is more stable. The bullwhip effect measurement result in four retails can be seen in Table 2.

TABLE 2. BULLWHIP EFFECT SCORE OF SINACH ORGANIC VEGETABLE IN FOUR PARTNERS RETAILS

| Retail name | Variable | Total | Average | STDV | CV | BE | Para-meter | Explanation |
|---|---|---|---|---|---|---|---|---|
| Top Cibubur | Order | 1,690 | 17.42 | 6.85 | 0.39 | 0.6190 | 1.013 | Demand |
| | Demand | 934 | 10.38 | 6.55 | 0.63 | | | |
| Total Buah Thamrin | Order | 4,090 | 42.16 | 19.97 | 0.47 | 0.6528 | 1.013 | Demand |
| | Demand | 2,067 | 23.22 | 16.75 | 0.72 | | | |
| Duta Buah | Order | 1,109 | 11.43 | 12.01 | 1.05 | 0.9459 | 1.013 | Demand |
| | Demand | 434 | 5.43 | 6.01 | 1.11 | | | |
| Allfresh GS | Order | 701 | 7.23 | 7.08 | 0.98 | 0.2979 | 1.013 | Demand |
| | Demand | 233 | 2.59 | 8.52 | 3.29 | | | |

Table 2 showed that the bullwhip effect score in the supply chain of spinach commodities in every retail had BE score smaller than 1.013 as a parameter score. It was mean that there was no bullwhip effect on order and demand fulfillment of spinach in partner retails. The highest average of BE score in the supply chain of spinach commodities happened in Duta Buah Retail that was 0.9459, while the lowest average of BE score happened in Allfresh GS that is 0.2979. Therefore, it can be said that Allfresh Gatot Subroto retail was the retail that had order data that closest to consumer demand. Thus, the acceptance and profit in Allfresh Gatot Subroto can be optimized. The reason was Allfresh Gatot Subroto was the main branch of Allfresh Company in Jabodetabek from many Allfresh shops in many locations, then it was natural if that branch has procurement and demand management performed by professional. Except for spinach, the result of the bullwhip effect measurement of organic horenso's supply chain can be seen in Table 3.

TABLE 3. BULLWHIP EFFECT SCORE OF ORGANIC HORENSO IN FOUR PARTNERS RETAIL.

| Retail name | Variable | Total | Average | STDV | CV | BE | Para-meter | Explanation |
|---|---|---|---|---|---|---|---|---|
| Top Cibubur | Order | 1,428 | 14.72 | 6.5 | 0.44 | 0.8462 | 1.013 | Demand |
| | Demand | 842 | 9.36 | 4.82 | 0.52 | | | |
| Thamrin Fruit Total | Order | 4,335 | 44.69 | 19.81 | 0.44 | 0.7719 | 1.013 | Demand |
| | Demand | 2,986.5 | 33.56 | 19.29 | 0.57 | | | |
| Duta buah | Order | 4,395 | 45.31 | 41.89 | 0.92 | 0.8519 | 1.013 | Demand |
| | Demand | 2,315 | 28.94 | 31.29 | 1.08 | | | |
| Allfresh GS | Order | 1,400 | 14.43 | 6.88 | 0.48 | 0.8276 | 1.013 | Demand |
| | Demand | 958 | 10.64 | 6.16 | 0.58 | | | |

Table 3 showed BE score on the supply chain of horenso commodities in every partner retail was smaller than 1.013 or less than its parameter score, thus it was mean that there is no bullwhip effect on organic horenso's supply chain at the retail level. The highest average BE score on horenso happened in Duta Buah that was 0.8419. While the lowest average BE score of horenso happened in Total Buah Thamrin, which was 0.7719. Therefore, it can be said that Total Buah Thamrin had a good management so that can provide horenso's needs close to the number of horenso's demand of the consumer. Thus,

it can be concluded that there was no bullwhip effect on this study and observation for spinach and horenso at the retail level. It can be provided with a BE score which lower than its parameter score, which was mean true, so there was no bullwhip effect. The differences between PT. SFO and retail analysis result showed that the bullwhip effect phenomenon did not always happen in every supply chain network at the same time since every level had different supervision management.

Because of that, it is important to do the bullwhip effect's score measurement in aggregate of institute level of the supply chain. That measurement was performed to discover the overall variability of vegetable demand of the supply chain network from upstream and downstream. The bullwhip effect score in every supply chain institute can be seen in table 4.

**TABLE 4. BULLWHIP EFFECT SCORE IN EVERY SUPPLY CHAIN INSTITUTE**

| Echelon/Institute | Bullwhip Effect score |
|---|---|
| PT Simply Fresh Organic | 1.56106 |
| Partner Retail | 0.94698 |

Bullwhip effect measurement in every supply chain institute of leaf organic vegetable intended to find out which institute had a higher bullwhip effect score and need quicker handling. Table 4 showed the bullwhip effect score measurement on the supply chain of vegetable commodities in PT. SFO was 1.56106 or higher than the bullwhip effect score on organic vegetable's supply chain at the retail level that was 0.94698. The BE score in PT. SFO tended to be higher than the average BE Score in retail because order variability tended to go up from the consumer to the supplier (Talitha, 2010).

Based on the calculation of demand and sales score at the company or retail level, it can be said that there was a bullwhip effect phenomenon in PT. SFO was upstream. This phenomenon was very impactful to the number of demands and sales of the company. Because of that, it needs to resolve the bullwhip effect phenomenon to optimize company profit. One of the strategies is to concentrate demand information for reducing the number of bullwhip effect frequencies. Technically, the solution is making demand data from downstream sites to be available in the upstream site. However, that solution does not completely remove the bullwhip effect. Even every chain had the demand information at the retail level, the bullwhip effect cannot be removed perfectly. Therefore it can be assumed that concentrate the information on customers' demand just reduce the bullwhip effect (Chen *et al.*, 2000). Yet, this solution is considered to be the most effective way to apply in organic vegetable's supply chain in PT. SFO. Technically, PT. SFO can determine which level of the supply chain on duty to be the center of information about demand and sales of leaf organic vegetables. In the future, periodically control must be carried out for the number of orders or demand for leaf vegetables. Information shared in detail between retailers and suppliers is believed can reduce the bullwhip effect as a whole (Wang *et al.*, 2005). Retailer as a final distributor played an important role to share actual demand information (Paik & Bagchi, 2007). This actual information is important for PT. SFO to become a basis to determine vegetable order to the farmer. The smoothness of information sharing, exchanging goods, and money, have a relevance that affects the success elimination

process of the bullwhip effect. Therefore, that smoothness becomes an important factor after every level's profit is balanced (Susanawati *et al.*, 2017).

## CONCLUSION AND SUGGESTION

The result of the bullwhip effect measurement was there was a bullwhip effect in PT. SFO while it did not appear at the retail level. Bullwhip effect phenomenon in PT. SFO has happened since rationing and short game gaming policy performed by the company to its partner retail. The reason, there was an inaccuracy of basic estimate data which caused an error in the customer demand forecasting process.

We can suggest that every supply chain of leaf organic vegetable members should keep the information to be transparent to guarantee the accuracy of forecasting basic data. That transparency must be performed in a central institute and its information data can be accessed by all supply chain network members. Therefore, it is required for PT. SFO and its partner to start using a computerized storage system.

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