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Collaborative Planning, Forecasting, and Replenishment (CPFR) to Reduce Bullwhip Effect: Case Study

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Abstract. Supply chain is basically an integrated system in the process of preparing and delivering products to consumers. This chain is also a network of numerous businesses that are interrelated and have a common objective. This company, which is engaged in the processing of soy sauce using soybeans as its raw material, produces sweet soy sauce and salty soy sauce. Production policy used in this industry was based on the number of requests at the store's sales area and the demand to anticipate fluctuating demand were added 10%. Inaccuracies in the number of requests result in a varied difference between the number of requests and the number of sales, causing overstocking when demand decreases or stockouts when supplies cannot meet demand or commonly known as the bullwhip effect. Based on these problems, this study aims to obtain the right production policy to minimize the bullwhip effect using the CPFR framework. The results of this study show that the bullwhip effect values for sweet and salty soy sauce are 0.812 and 0.814, respectively.

Keyword: Supply Chain Management, Collaborative Planning, Forecasting, and Replenishment (CPFR), Bullwhip Effect.

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1. Introduction

The network of companies that develop products and deliver them to end users is called a supply chain [1]. Supply chain management will be successful if there is good integration and coordination of all parties that are involved from upstream till downstream. Upstream and downstream that stated above, namely from the company until the consumers. Which means this is crucial and the effectiveness of a supply chain needs to be maintained [2].

When talking about the supply chain, the demand fulfillment chain occurs in downstream from raw material suppliers to retailers and ends at consumers. Meanwhile, the upstream chain occurs from the consumer to the supplier, contains information about the degree of demand fulfillment at each link in the supply chain. The flow of information from consumers is possible for information distortion to occur because only retailers are dealing directly with consumers. So that

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information on the number of real consumer needs is owned by retailers, while agents, producers and suppliers become less accurate. As business chain complexity increases, information distortion along the supply chain can increase. Distortion of information in each supply chain will have impact on order quantity decisions, inventory policies and cost.

Retailers, wholesalers, distributors, manufacturers and suppliers are one of the simple supply chain systems. Demand estimation and inventory requirements are triggered by end-user demand. Retail stores observe the needs of product requests from end users. From this remark, retailers should do a request for products to the wholesalers. Product demand information obtained is used by wholesalers to estimate product demand for distributors. Since wholesalers do not have direct access to information about end users, the estimates used by distributors are based on historical data from retailers, and so on until the estimated supply of raw materials from manufacturers to suppliers. The presence of supply and demand fluctuations causes problems in the early stages of the supply chain system, i.e., retail outlets. This difference can arise due to both external factors beyond the control of the retailer and internal factors generally caused by inaccuracies in quotations. To anticipate the occurrence of fluctuations in inventory demand, retailers stockpile inventory in case of anticipated shortages. Downstream inventory fluctuations at any stage of the supply chain system impact larger upstream fluctuations. Upstream stocks become more volatile, forming a bullwhip-like pattern.

Constraints in integration and coordination that occur along the supply chain cause a bullwhip effect. The bullwhip effect is a phenomenon in which demand fluctuates more as we move up the supply chain, meaning that there are differences in the amount of consumer demand in each period, whether it's less or more, which can affect all levels. This bullwhip effect can occur throughout the supply chain for any product. The problem of the bullwhip effect is also felt by a food industry that processes soybeans into soy sauce products. Soy sauce is a dark brown or black liquid product that has a salty or sweet taste [3].

This soy sauce producing company produces its products on a make to stock basis. Currently the company implements a production policy based on the number of requests from the sales area of the store and the estimated demand plus 10%. However, the number of requests that fluctuate and cannot be predicted results in distortions in the company's supply chain and impacts on the number of requests that become inaccurate. The inaccuracy of the number of requests causes a difference between the number of requests and the number of sales and results in overstocking when demand decreases and stockouts when supplies cannot meet demand or known as the bullwhip effect. The emergence of the bullwhip effect will result in inefficiency in the company's supply chain due to additional inventory costs. To minimize the occurrence of the bullwhip effect, it is necessary to carry out an analysis related to the right production policy. This research will use the CPFR method in determining production policies which include the size of lot orders and safety stock to minimize the occurrence of the bullwhip effect in the company's supply chain.

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2. Literature Review

2.1. Supply Chain

Supply chain is the involvement of manufacturers, suppliers, distributors, retailers, and transportation, information and other logistic service providers in delivering goods to consumers. [4][5]. A supply chain is an integrated process in which many entities work together to source raw materials, process them into final products and distribute them to retailers and customers. A supply chain is not only the entity of supplier, manufacturing, customer and delivery processes, but also the system by which an organization sells its products and services to consumers [6]. The structure of the supply chain is divided into three layers as we can see below [7]:

- Upstream supply chain, is a part that consists of a series of suppliers starting from the first level supplier to the final level before going into manufacturing.
- Internal supply chain, is a part that consists of a series of processes that occur in manufacture to transform inputs from suppliers into valuable outputs.
- Downstream supply chain, is the final part of the entire process chain for delivering products to end consumers.

There are three types of flows in the supply chain that need to be managed. It is the flow of goods, money and information from upstream to downstream and vice versa. Conceptually, Pujawan and Mahendrawathi describe the supply chain model as shown in Figure 1 [1].

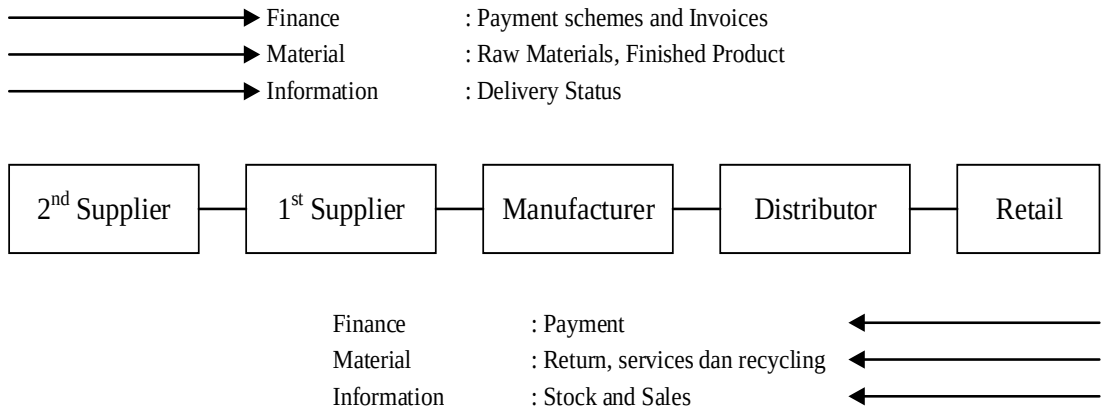

Figure 1 Supply Chain Conceptual Illustration

The figure above shows that supply chain management is the coordination of goods, money, and information between network actors working together to enable consumers to receive goods. This can be explained as follows.

- The flow of goods involves the flow of physical (material) products from suppliers to consumers or vice versa, such as product returns, services and recycling.
- demand forecasting, order submission, delivery status reporting, and sales were included in information flows.

- credit card information, credit terms, payment schedules, ownership restrictions, and proof of payment were also included in financial flows.

2.2. Bullwhip Effect

Supply chain demand information changes frequently as it travels from one component or supply chain node to another. Changes such as delays, amplification, and distortion of demand signals are known as the bullwhip effect. The term Bullwhip Effect was first used by Procter & Gamble (P&G) executives where experts were surprised by the increasing degree of variability in the distribution of orders [8]. The bullwhip effect is the increase in demand volatility at all levels of the supply chain due to information bias when circumstances indicate that firms do not have accurate demand information [9]. The bullwhip effect is of great importance to manufacturers, distributors, and retailers. Facilities must increase safety stock of orders to provide service levels, increasing costs for storing too many goods, inefficient use of resources, labor and transportation critical because it becomes.

There are many factors that can lead to bullwhip effect. Identified 4 main causes of the bullwhip effect, namely:

- Demand forecast updating, updating the demand forecast impacts the accuracy of the forecast because companies are up-to-date on customer demand and current market conditions.

- Order Batching, retailers that sell products on a small scale will order a considerable amount of products over a predetermined period of time. This causes distributors to receive orders that are more volatile than the demand faced by retailers.

- Price Fluctuation, forward buying by retailers in response to price reductions results in increased sales figures as a result distributors will order in large quantities from factories. The factory responded by increasing production and placing orders with suppliers to anticipate raw material shortages.

- Rationing and Shortage Gaming, sellers will do rationing when demand is higher than supply. The rationing in question is fills one hundred percent of the customer's order but only a certain percentage of the ordered quantity.

2.3. Collaborative Planning, Forecasting, and Replenishment (CPFR)

Collaborative Planning, Forecasting and Replenishment (CPFR) enables suppliers and retailers to work together on demand planning and forecasting to ensure that members of the supply chain receive the right amount of raw materials and finished goods when they need them. increase. business execution model. Joint planning is divided into four main areas: [10]

- Strategy and planning for collaboration on supply and inventory levels.

- Forecasting demand and managing suppliers and inventory.

- Implementation and analysis of results.

- Adjustments to the desired strategy. This activity focuses along the supply chain from the seller to the buyer to the customer.

CPFR is a supply chain improvement tool, specifically relevant to all SCM participants, to optimize inventory reduction, logistics costs and efficiency across the supply chain. CPFR uses co-management to share critical supply chain information between suppliers and retailers (sellers and buyers) who work together to meet end-user needs. The main feature of CPFR is having a strong relationship to the calculation on the demand side. The planning (planning) and forecasting components require an intensive exchange of information, not only at the logistics level, but also in management planning, marketing and finance. Senior management can use CPFR for its advantages in efficiency in strategic SCM [11].

3. Methodology

The object of research is one of the soybean processing industries into products with 600 ml bottled sweet soy sauce and 600 ml bottled salty soy sauce. This research focuses on measuring and Use the CPFR method to reduce the value of the bullwhip effect. Before measuring bullwhip value using the CPFR, forecasting the number of product requests is done first. Forecasting is done at the aggregate level and the disaggregation method used is “cut and fit”. The variables of this research are the amount of manufacturing production and the amount of sales from the marketing area. The research was carried out with the CPFR flow as shown in Figure 2.

The stages of solving the bullwhip effect problem using the CPFR model include (1) Front-End Agreement (companies make agreements and policies before trading), (2) Joint Business Plan (at this stage , the company establishes a trading strategy, goals and tactics including product types, minimum orders, lead times, and delivery frequencies), (3) Sales Forecast (this stage is carried out by making sales forecasts to the parties concerned in trade to be able to create policies production), (4) Identify Exceptions for Sales Forecast (this stage is carried out by looking for exclusion criteria in sales forecasting such as errors in sales forecasting), (5) Resolve/Collaborate on Exception items (at this stage testing of forecasting results is carried out sales that have been selected to obtain data accuracy), (6) Create Order Forecast (at this stage it is carried out by making production policies for parties involved in the supply chain), (7) Identify Exceptions for Order Forecast (at this stage it is carried out by analyzing production policies that have been made can handle fluctuating requests), (8) Resolve/Collaborate on Exception items (this stage is done by calculating the production policies that have been achieved and can minimize the occurrence of demand amplification in the supply chain), and (9) Order Generation (on this stage will be seen whether the results of orders that have been produced can meet demand).

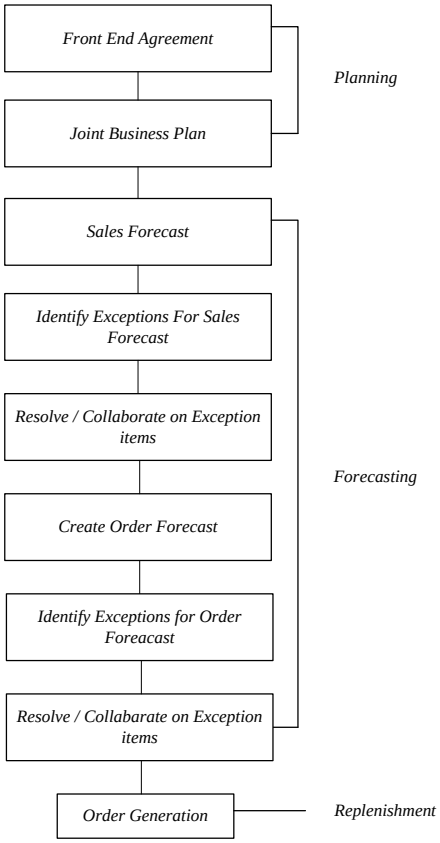

Figure 1 CPFR Framework

4. Result and Discussion

4.1. Forecasting

The type of research used is Action Research. Action Research is research conducted to obtain practical findings for operational purposes. The purpose of this research is to make operational decisions to develop new skills or new approaches [4].

Demand forecasting is done by looking for the smallest error among the 4 forecasting methods namely Trend Linear, Moving Average, Exponential Smoothing and Winter's Model. Forecasting is done on soy sauce demand data for the 2019 period. Based on this forecast, forecasting with the smallest error is obtained by using the Winter's Model. The use of this forecasting method is based on the influence of data trends (trends) and increases or decreases in data over a certain period which is called seasonal. The following is a recapitulation of each forecasting method which will be shown in Table 1.

Table 1 Forecasting Error Recapitulation

Method	Forecasting Error		
	MAPE	MAD	MSD
Trend Linear	5,37323	11445500	244409000000000
Moving Average	8,91131	19942200	587980000000000
Exponential Smoothing	6,95483	15284000	432033000000000
Winter's Model	2,68044	5479060	42214300000000

Based on this forecast, the forecast with the smallest error is obtained by using the Winter's Model, namely the value of MAPE (Mean Absolute Percentage Error) with a value of 2.68044, MAD (Mean Absolute Deviation) with a value of 5479060 and MSD (Mean Square Displacement) with a value of 42214300000000. By selecting Winter's Model, it has the smallest error so forecasting using this method can detect the accuracy of the forecasting results.

The verification and validation carried out on the forecasting results using the winter's model method shows that this method can be relied upon to predict the demand for soy sauce for several future periods. This can be seen from the results of verification with the moving range chart which shows the four conditions that show outside the control are not met. The validation results using tracking signals show that the values of tracking signals are in the range -6<TS<6, so it can be concluded that the Winter's Model method is feasible to use in predicting soy sauce products. The results of forecasting demand with the Winter's Model method are as follows

Table 2 Forecasting Results with Winter's Model

Forecasting Result By Winter's Model						
Period	1	2	3	4	5	6
Forecast demand	143,506,525	143,332,559	156,755,078	162,668,723	162,493,308	154,248,636
Period	7	8	9	10	11	12
Forecast demand	186,975,107	189,032,057	161,077,373	146,568,164	179,404,158	169,209,340

4.2. Disaggregation

Forecasting results using the Winter's Method is a prediction of the total soy sauce product. Each demand for sweet and salty soy sauce products is obtained through a disaggregation process. The proportion of sweet soy sauce is 69% and 31% salty soy sauce. The demand for sweet and salty soy sauce can be seen in Figure 3.

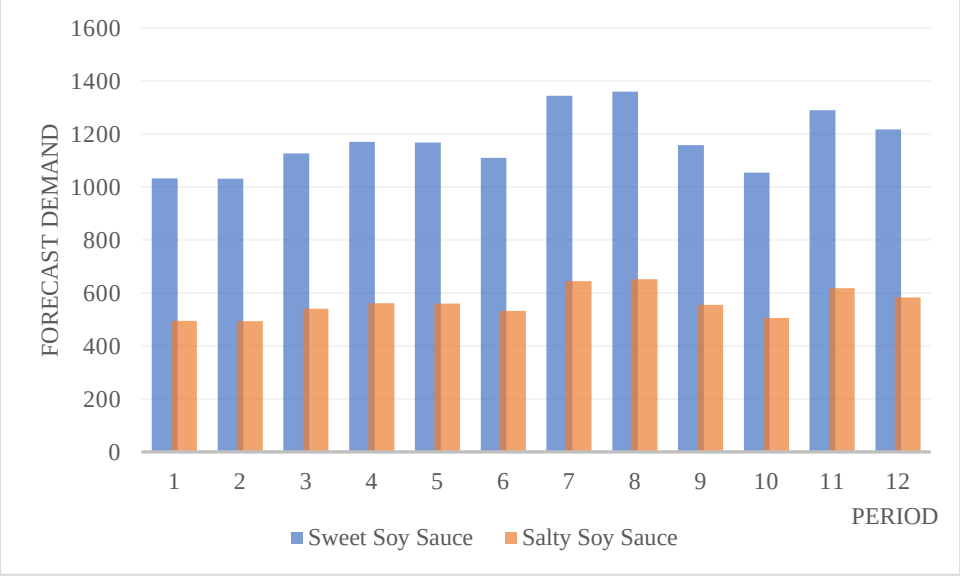

Figure 2 Product Demand Aggregation Results

This study uses inventory levels from gross demand determined based on forecast results and safety supplies levels. To anticipate increased consumer demand and its level of uncertainty. Safe stock with 262 dozen sweet soy sauce and 126 dozen soy sauce.

4.3. Bullwhip Effect Score Before Using CPFR Method

The production policy implemented by the company previously experienced a bullwhip effect as a result of distortion of demand information from distributors to production (manufacturing) departments. The existence of demand variability that arises from the comparison of order results with the number of requests results in a large enough inventory and causes inventory costs. The magnitude of the bullwhip effect value is obtained from the quotient of the demand variance coefficient with the sales variance coefficient can be seen in Table 3.

Table 3 Bullwhip Effect Value with the Company's Actual Method (Before using CPFR Method)

Method	Product	Order	Demand	Bullwhip Effect Score
		CV Order	CV Demand	
Addition of 10 percent	Sweet soy sauce	0,11188138	0,011458922	1,12
	Salty soy sauce	0, 14062404	0,097035356	1,45
No Additions	Sweet soy sauce	0,11342344	0,101881383	1,11
	Salty soy sauce	0,14048317	0,097035356	1,45
Addition of 5 percent	Sweet soy sauce	0,11251333	0,101881383	1,10
	Salty soy sauce	0,14019633	0,097035356	1,45

The table above shows that the resulting bullwhip effect value is greater than one, where there is an amplification of demand for the product. This is due to an increase in demand variability in the supply chain in the conditions under which it is carried out. The greater the value of the demand variance coefficient, the greater the value of the bullwhip effect. Conversely, the smaller the value of the variance coefficient of demand, the smaller the value of the bullwhip effect.

4.4. Bullwhip Effect Score After Using CPFR Method

Demand data from forecasting results will be used to calculate the value of the demand variance coefficient. Based on calculating the data, This indicates that the variance factor has decreased compared to the value of the variance factor before running the CPFR method. In this study, inventory is determined based on forecast demand and safety stock. This is in anticipation of growing consumer demand. The results of the bullwhip effect prediction calculation are shown in Table 4.

Table 4 Safety Stock

Product	Demand			Supply			BE Score
	Average	Standard deviation	Coefficient of variability	Average	Standard deviation	Coefficient of variability	
Sweet	1171.6	112.9	0.097	1433.58	112.90	0.08	0.812
Salty	561.7	54.3	0.097	687.67	54.30	0.08	0.814

From the table above, the values of bullwhip effect for sweet soy sauce and salted soy sauce are 0.812 and 0.814, which can minimize the occurrence of overstock and shortage without demand enhancement. company. A bullwhip effect value greater than 1 means that the demand for that product has increased.

5. Conclusion

The phenomenon of the Bullwhip Effect is that occurs in the soy sauce producing industry causes supply chain inefficiencies due to the large inventory costs. The application of the CPFR method in this study has proven to be able to minimize the occurrence of overstock and stockout in companies based on the resulting bullwhip effect value of not more than 1 (the bullwhip effect value for sweet and salty soy sauce is 0.812 and 0.814). The scope of discussion in this study is only carried out on the manufacture to the distributor. In the future, researchers can conduct thorough research starting from suppliers, manufacturers, to distributors.

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