Analysis on Causes and Countermeasures of Bullwhip Effect

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Abstract. Bullwhip effect is an inevitable phenomenon in supply chain management, because of its objective existence. This phenomenon is very common and harmful to make the operating costs of enterprises double and become one of the main concerns of many enterprises. In this paper, the causes of the bullwhip effect are explored through the methods of literature research and investigated consultation to weaken the bullwhip effect. This paper analyzes the key countermeasures with Wal-Mart successful logistics management case. And according to the reason of bullwhip effect, a mathematical programming model of maximizing the efficiency of supply chain is established, which provides a way to solve the negative effect of bullwhip effect and has certain reference value.

1 Introduction

Bullwhip Effect refers to a kind of distortion occurring in the process of transmitting order information upstream, which is a bigger fluctuation in upstream order quantity caused by the fluctuation of downstream demands.[1] This is a common phenomenon in supply chain.[2, 3] The existence of bullwhip effect makes it difficult for enterprises to grasp market demands, causing an overstock and reducing the operational efficiency for the whole supply chain.[3-5] The best way to solve bullwhip effect is to reduce knots of supply chain as far as possible, thus to greatly ensure accuracy of information. Using efficient supply chain management system can reduce bullwhip effect and realize real-time response, directly reducing operating costs of enterprises.[6] The factors causing bullwhip effect include the following several aspects which are demand forecast amendment, fluctuations in prices, order quantity decision, shortages game, inventory imbalances, lead time, etc.

2 Bullwhip effect in supply chain

2.1 What is the "bullwhip effect"

In the early 1990s, P&G discovered a wonderful phenomenon, the United States of infant birth rate and baby diaper usage has remained stable, but Procter & Gamble distributors to their factory orders volatility is more pronounced, and Procter & Gamble The volatility of orders placed with their suppliers is greater. The degree of order and inventory levels moving up the supply chain is always increasing - from customers to retailers to distributors to suppliers to suppliers and even suppliers. In addition to Procter & Gamble, Hewlett-Packard found slight fluctuations in its sales of its retail stores, And HP's printer division to its integrated circuit sector orders fluctuate even greater. All this shows that the demand for information in the transmission process has been seriously distorted, as shown in Figure 1. In addition to Procter & Gamble, Hewlett-Packard found slight fluctuations in its sales of its retail stores, And HP's printer division to its integrated circuit sector orders fluctuate even greater. All this shows that the demand for information in the transmission process has been seriously distorted, as shown in Figure 1.

Fig.1. Schematic diagram of bullwhip effect.

From the above chart we can see that the slight changes in customer demand back to the upstream business order fluctuations are enormous, which is the bullwhip effect appeared in the supply chain phenomenon, and the more the level of the supply chain, the more obvious of bullwhip effect. Because of this phenomenon, upstream suppliers often need to maintain more inventory levels than downstream suppliers.

In summary, the bullwhip effect is a typical complex phenomenon caused by the uncertainty of the supply chain is the distortion of demand information in the supply chain to convey a description of the image. When the information flow from the final client to the original supplier side, can not effectively and accurately achieve information sharing, making the information distorted and level-by-step amplification, resulting in a great demand for information fluctuations, such information distorted like a rejection of the bullwhip, the root of a small change, it will lead to huge changes in the tail. Therefore, some people will link "bullwhip effect" and "butterfly effect".

2.2 The harm caused by bullwhip effect

Bullwhip effect exists in the supply chain objectively with high risk, it brings the consequences of self-evident. Mainly in the following aspects:

Inventory backlog. Distortion of demand information, making the company's inventory and the actual demand for a conflict, results in a large backlog of inventory.

Increased operating costs. Demand information volatility, enterprises to avoid the risk of stock, to expand production capacity to meet the demand for orders, which undoubtedly greatly increased the total cost of the supply chain.

Reduced customer service levels. Amplify the distortion of the demand information makes it difficult for the nodes of the real needs of the market to make accurate forecasts and the right decision, can not really meet customers' needs.

In summary, the bullwhip effect makes the supply chain operation disorders, the work of the supply chain has had a significant negative impact, we are very necessary to further analysis of the causes of bullwhip effect and propose solutions.

2.3 The Cause of Bullwhip Effect

Professor Stein, came from the Massachusetts Institute of Technology, did a famous experiment - the beer experiment. In the experiment, there are four students representing consumers, producers, wholesalers and retailers, respectively, to form a simple supply chain. The requirements of the experiment are: any upstream and downstream enterprises can not exchange any business information, Only downstream enterprises are allowed to transfer orders to upstream enterprises, consumers can only order to the retailer. The result of the experiment shows that the asymmetric information of each node and the maximization of its own interests make the demand information distorted in the supply chain, which is the bullwhip effect. There are several reasons for this phenomenon:

2.3.1 Demand forecast information single and demand information distortion

As shown in the beer experiment, each node is always based on its direct downstream demand information as the basis for their demand forecast, which leads to the future demand forecast is not accurate. And in order to avoid out-of-stock risk, companies will always increase part of the inventory, resulting in the demand inflated, bullwhip effect followed.

2.3.2 Supply chain fluctuations in the price of each node enterprises

Retailers and distributors in the face of price volatility, discounts or promotions, natural disasters, etc., tend to take the practice of increasing inventories, so that orders are far greater than the actual demand. For consumers, they may change purchases during periods of price volatility, but this does not reflect consumers' long-term real needs, since during this period they postpone or advance some of their needs. For example, the annual holiday, businesses will be

promotional, consumers will postpone some of the pre-holiday demand, will also be part of the demand ahead of time, in order to focus on holiday spending, so that changes in demand will be very large, causing Bullwhip effect.

2.3.3 Bulk order and lead time

In the supply chain, each enterprise will order to its upstream. Normally, after receiving only one order, the seller will not immediately order the goods from his supplier, they will consider the inventory and freight costs in one cycle or aggregate to a certain number of re-orders. In order to reduce the frequency and reduce the cost of ordering, vendors tend to increase the amount of orders.

Because frequent orders will increase the workload and cost of suppliers, suppliers often require vendors to achieve a cycle or a certain number of orders after the order. To prepare for the occasion, vendors tend to increase the order quantity, thus leading to the bullwhip effect.

Fig.2. The Relationship Between Order Lead Time and Prediction Error.

Because the order information needs to go through these links: Customers - Retailers - Wholesalers - Manufacturers - Suppliers for its information processing. The process will inevitably lead to delays in information and logistics. So the order quantity of information is not timely amended, for the upstream business, to consider the delay phase of the demand, will naturally increase the safety stock. Therefore, the companies in the expected inventory are included in the lead time, the longer the lead time, small changes in inventory changes caused by the greater. As shown in Figure 2, with the increase in the lead time of the order (from right to left), the prediction error gradually increases, and will affect the size of the inventory, the entire supply chain nodes are very unfavorable.

2.3.4 The complexity of the supply chain itself and multi-level

Supply chain is composed of many suppliers, manufacturers, vendors and customers of a complex network of chain system, the demand information pass up from the end of the network chain to another end. Under the dual effects of external market environment interference and conflict of objectives among internal stakeholders, the demand information presents the complexity characteristics of time and space evolution each other, such as uncertainty, delay, nonlinearity, dynamicity, time interleaving, transfer structure and so on.

In addition, the supply chain has a multi-level, at all levels of enterprises will be set up safety stock, the accumulation of multi-storey system will increase the amount of inventory products in the supply chain, as shown in Figure 1. This, in turn, has slowed down the response to market volatility and led to the bullwhip effect when it comes to raising the level of customer service, especially the level of stock availability and improving safety stock.

2.3.5 Poor information exchange and information game

In the beer experiment, any upstream and downstream enterprises can not exchange any business information, companies can not grasp the real needs of the downstream and upstream supply capacity, but to store their own goods. At the same time, if the supply chain can not achieve the availability of stock exchange and transfer allocation, can only have their own high inventory, which will undoubtedly lead to bullwhip effect.

Supply chain nodes Enterprises are interdependent, interest-related partnerships. However, under incomplete information, as the rational participants, in order to maximize their respective interests, each node enterprise will compete and compete with the demand, price, inventory, product development and other information. The results of the game is one of the causes for the bullwhip effect.

2.3.6 The product in short supply

Another mechanism that causes the bullwhip effect is a shortage of products. For example, during the market introduction period of the best-selling new products, the manufacturer will implement a sales quota system, and each retailer can get only a fraction of the order quantity from the manufacturer. Aware of the quota behavior of suppliers,

even if retailers know that they do not need and can not sell additional products, will continue to expand its order quantity, known as a false order. Manufacturers receive more orders than their forecast demand, will further invest in expanding production. Unfortunately, when the real demand appears, the supply may be far more than demand, false orders will be revoked by retailers, suppliers can only sell a very low price of the remaining products.

3 The countermeasures and case analysis of weakening bullwhip effect

For the obstacles which lead to the bullwhip effect, we need began from overcoming these causes to start. Therefore, the basic countermeasures to weaken the bullwhip effect are: to achieve information sharing, to avoid the multi-demand forecast; implementation of outsourcing services to shorten the lead time; reduce bulk orders; reduce price promotions, avoidance of variability; circumvent short game situations; Inventory responsibility and so on. This paper focuses on three strategies to effectively weaken the bullwhip effect, the first two for the establishment of supply chain strategic alliance and application of Internet of things, combined with examples of Wal-Mart's logistics management analysis. The third one is the supply chain efficiency maximization model, which combines various factors of bullwhip effect, and provides a valuable method to solve the practical problem of bullwhip effect.

We must make clear that the bullwhip effect can not be completely eliminated from the supply chain, but if the method properly, realistic, you can greatly weaken the bullwhip effect on the supply chain management of the negative impact.

3.1. The establishment of supply chain strategic alliance

For the demand forecast is not accurate and the information communication is not smooth, we can adopt the strategy of establishing the supply chain strategic alliance. The traditional upstream supply chain enterprises can obtain the demand information only from the downstream enterprises. The information flows are single and not flexible enough. If the upstream and downstream nodes enterprise information is symmetry and interoperability, the formation of a more stable supply chain strategic alliance, then forecast the accuracy of demand will be greatly improved. In this way, the structure of the supply chain will be as follows. See Figure 3 below.

Fig.3. Supply chain strategic alliance.

In this regard, Wal-Mart and Procter & Gamble's production and marketing strategic alliance to fully reflect the advantages of this logistics model and a strong foundation. P & G is the world's largest manufacturer of daily necessities; Wal-Mart is the world's largest commercial retail enterprises. The cooperation between them is not smooth sailing, also experienced the "cold war", Procter & Gamble is always trying to control the Wal-Mart's sales prices and sales conditions to its products, and Wal-Mart to be outdone, threatened to end Procter & Gamble product sales, or left it the worst shelf.

However, the two sides soon realized the benefits of in-depth cooperation. Procter & Gamble chose to cooperate with Wal-Mart to establish a strategic alliance of production and marketing partnership. As the main organization for the implementation of the cooperation, Procter & Gamble and Wal-Mart formed a special cooperation team of about 70 people, including personnel from the financial, circulation, production and other functional departments, the team was sent to Walmart to implement collaborative management. Wal-Mart began in 1989 to implement the supply chain management for Procter & Gamble, the specific form of the two sides are through EDI (electronic data interchange) and satellite communications to achieve accurate understanding of networking information. With the help of information systems, Procter & Gamble in addition to quickly know Wal-Mart logistics center diaper inventory, but also to keep up-to-date diaper stores in Wal-Mart sales, inventory, price and other data, so accurate information base allows Procter & Gamble formulate development of market demand in line with the production and research and development plans timely, but also on the Wal-Mart's stock for replenishment, to prevent excessive inventory and out of stock status. At the same time, Wal-Mart on the basis by getting information from Procter & Gamble through EDI, can make decisions timely of decision-making shelves and purchase of goods. Wal-Mart gives the logistics center or warehouse management right to the Procter & Gamble. In this way, Wal-Mart not only do not engage in specific logistics activities, and because the two sides do not have on each transaction conditions (such as distribution, price issues, etc.) to negotiate, greatly reducing the entire business process time of goods from the purchase, storage, sorting, replenishment to sales of.

Wal-Mart and Procter & Gamble's production and marketing strategic alliance, to reduce unnecessary inventory, save the cost of circulation, to achieve the information sharing and elimination of information game, making the two companies get a win-win situation, have a absolute effective control of the bullwhip effect.

3.2 Application of Internet of things

Internet of things is a network which through the radio frequency identification, infrared sensors, global positioning systems, laser scanners and other information sensing equipment, according to the agreement, to connect any object with the Internet and exchange of information and communication to achieve the intelligent objects Identification, location, tracking, monitoring and management.

Internet of things is one of the products of logistics network. The so-called logistics network is simply the logistics of information, network management, to achieve logistics information's real-time cross-regional transmission. In the logistics network system, the weakening of the advantages of the bullwhip effect are:

1. Logistics nodes implement information management in the general. Each node's information is the base of logistics system information in the logistics process, through the analysis and mining of logistics information, to maximize the use of effective information on logistics activities management.

2. The whole system has unlimited openness. The entire system is built on the Internet, can quickly exchange data, with unlimited openness and expand capacity.

3. Information flow in the entire logistics process to guide and integrate the role. Information flow throughout the entire logistics activities in the logistics process has played a pre-forecast, after the feedback role, greatly reducing the error, making a significant decline in the pause time.

4. The system has obvious scale advantage. In the logistics network, the system to form a network structure, large-scale joint operations to reduce the overall operating cost of the system.

Here, have to mention Wal-Mart's logistics network construction. The world's largest retailer Wal-Mart is the world's first group to achieve 24-hour computer logistics network monitoring of the enterprise. In the 1970s, Wal-Mart established a logistics management information system to handle system reports, which effectively speeded up operations. In the early 1980s, Wal-Mart and Hughes co-operated with the launch of logistics communication satellites, logistics communication satellite makes the global networking, Wal-Mart therefore had a jump development. In 1983 when Wal-Mart uses a POS machine, full name Point Of Sale, is the starting point of sales data system. After the establishment of the EDI, the electronic data interchange system, paperless operation, all the information all in the computer operation. In 1986, when it established a QR, known as the rapid response mechanism, quickly pull the market demand. In 2004, Wal-Mart asked its top 100 suppliers to use radio frequency identification technology (RFID) when sending pallets and crates to its distribution centers.

RFID technology is based on computer technology and communication technology of highly automated information and data collection of integrated technology. Is the application of the main technology of things. RFID has many advantages: it is not restricted to the line of sight. Video identification card has a strong ability to read and write, while difficult to copy and intelligence is very high. RFID does not require human intervention to complete the identification work, while moving up to 500km per hour to identify the moving object, you can also identify multiple RF tags at the same time.

With these advanced information technology of the Internet of Things, Wal-Mart effectively weakened the information can not be shared and lagging behind the possibility of lead to bullwhip effect, making the supply chain more rapid and smooth flow of information from upstream to downstream transmission more accurate, So that even more powerful enterprises, has made leading and long-term development.

3.3 Establish a supply chain efficiency model

In order to reduce the impact of bullwhip effect, we should establish a supply chain efficiency model, the bullwhip effect makes the efficiency of the supply chain greatly reduced, The establishment of this model makes the indicators adjusted to maximize the efficiency of the supply chain, that is, the objective function of the efficiency model to determine the maximum efficiency of the supply chain as a whole, you can weaken the bullwhip effect to a certain extent.

The objective function is established

$$\text{Max } Z = f(x_1, x_2, x_3, x_4, x_5, x_6) \quad (1)$$

Among them, $x_1, x_2, x_3, x_4, x_5, x_6$ respectively on behalf of the demand forecast correction, order batch decision-making, price fluctuations, shortage of information game, lead time and supply chain structure, Corresponding to the above analysis of the bullwhip effect of the causes. F represents the parameters of each node in the supply chain, such as firm size, efficiency, and the number of workers, for the multi-factor matrix.

Constraints established:

Suppose there are five main nodes in a supply chain, namely raw material suppliers, producers, distributors, third-party logistics enterprises, and retailers. According to their respective infrastructure conditions, operating conditions, financial strength, operational efficiency, technical conditions and other major factors, it forms the formation of each node enterprise conditional constraint equation and the final formation of the objective function and constraint equations.

Objective function:

$$\max Z=c_1x_1+c_2x_2+\cdots\cdots\cdots c_6x_6$$

(2)

$$\left\{\begin{array}{l}\sum_{i=1}^6Ax_i\leq b\\A=(P_1,P_2,P_3,P_4,P_5)\\b=(b_1,b_2,b_3,b_4,b_5)^T\end{array}\right.$$

(3)

In the constraint equation, A denotes the condition factor of each node enterprise, which is expressed by a matrix. B denotes the upper limit of the comprehensive limiting factors of each node enterprise.

The knowledge of operational research is used to solve the efficiency model function to determine the optimal efficiency of the supply chain under the influence of the variable factors, and the conditions that each node enterprise should have in order to weaken the negative effect of the bullwhip effect and quantify the harm caused by the bullwhip effect, to bring a positive effect for the supply chain management. You are free to use colour illustrations for the online version of the proceedings but any print version will be printed in black and white unless special arrangements have been made with the conference organiser. Please check with the conference organiser whether or not this is the case. If the print version will be black and white only, you should check your figure captions carefully and remove any reference to colour in the illustration and text. In addition, some colour figures will degrade or suffer loss of information when converted to black and white, and this should be taken into account when preparing them.

4 Concluding remarks

Economic informationization and globalization have brought competition among supply chains for enterprise commercial competition. The survival and development of enterprises largely depends on whether the supply chain is running smoothly. While the bullwhip effect has brought great harm to the supply chain. Based on the analysis of the causes of the bullwhip effect and the case of Wal-Mart, this paper focuses on the countermeasure of weakening the bullwhip effect, and establishes a mathematical model to provide some reference for enterprises to reduce the harm caused by bullwhip effect.

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