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BULLWHIP EFFECT IN SUPPLY CHAINS

ABSTRACT

The system which connects all the elements between the producer and the consumer is called the supply chain. This definition of the supply chain shows its complexity, dynamics and uncertainty. Successful operation of supply chains requires the best possible coordination of its elements, which obviously indicates the utmost importance of the information flow along them. The operation of supply chains on the whole has to be more successful than the operation of their individual elements. It should be noted that such a complex process may give rise to a series of problems, unwanted events, as well as substantial reduction in profits and the level of service. One of such unwanted phenomena which may occur in the supply chain is the "bullwhip effect". This is a possible increase in the diversity of orders which occurs when we move along the elements of the supply chain (from the customers' orders to the producers' orders). The work analyses the processes within the supply chains and the occurrence of the bullwhip effect. The main causes of the bullwhip effect that we encounter daily in the supply chains have been clearly defined. The paper also presents the main negative consequences of such a disturbance within the supply chains, and provides possible solutions for avoiding the bullwhip effect.

KEY WORDS

supply chains, bullwhip effect, distribution

1. INTRODUCTION

The supply chains include all the participants and processes in satisfying the demand of end users: transport, stocks, wholesalers, retailers, distributors and producers. A great number of participants results in the versatility of interrelations and processes, dynamic feature, uncertainty and stochastic feature of the flow of goods and information, and many control points prove that the supply chains have to be considered as complex systems in which coordination is the key of success.

Very important processes of the supply chains include ordering and delivery of the purchased goods.

These processes are multiply interwoven and their disturbance may lead to undesired consequences.

One of them is also the "bullwhip effect" in which the fluctuations of orders increase as we move up along the supply chain. The main cause for the occurrence of bullwhip effect is the insufficient flow of real information between the elements of the supply chain, and if there is no attempt to prevent the bullwhip effect it is certain to appear in every supply chain.

2. SUPPLY CHAIN

Supply chains are complex logistic systems in which raw materials are converted into final products and distributed to end users. Supply chains include the raw material suppliers, producers, warehouses, distribution centres and retail shops.

Figure 1 shows a typical supply chain in which the production and the distribution system are composed of two phases. In the production system, the raw materials and semi-products are produced in two plants, whereas final products are assembled in the third factory. The distribution system consists of two central distribution centres which are supplied directly from the factory, and in turn each of them supplies two regional distribution centres. From these regional distribution centres the final products are distributed to retail shops, i. e. to the end users.

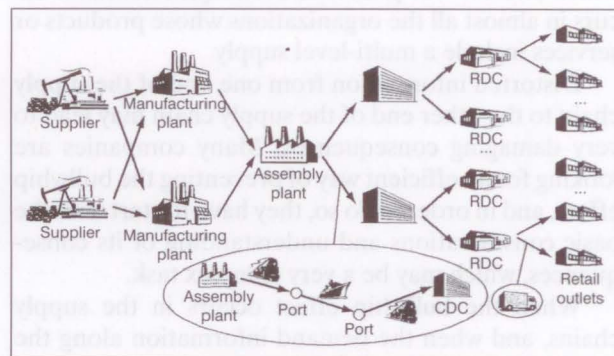


Figure 1 - Presentation of a typical supply chain

Of course, depending on the product and the demand the supply chain can be differently designed, and may contain more or fewer elements.

Partners within a supply chain share information which increase their capability to jointly satisfy all the consumers' needs. This shows that the information technologies represent the key to success along an integrated supply chain. In practise there may be fear and resistance to the idea that key information are shared among the partners, but the majority of these fears fade away if the partners share similar information, values and common visions. Such exchange of information and experience stimulates the creation of an efficient supply chain, which operates on a "know-how" principle. The objective is to make sure that the supply chain is in fact better than the sum of its elements.

The supply chain connects the suppliers and consumers during the entire process of production and distribution, and as such requires business transformation in which the managers try to eliminate uncertainty and to use the advantage using the suppliers and the consumers, evaluating the best supply price and balancing the professionalism and possibility during the entire process within the supply chain.

3. BULLWHIP EFFECT

Bullwhip effect was noticed for the first time at the "Procter&Gamble" (P&G) company. While testing order samples for one of the most sold products, their logistic experts noticed certain fluctuations in the flows of goods, but these variances were not especially excessive. Nevertheless, the experts were surprised by the increased level of variability in the distribution of orders. When they checked, namely, the P&G data against their raw material suppliers, they discovered even greater changes of variables. At first glance the obtained results showed no sense. While the consumers used the product at a constant pace, the order variables (demand) in the supply chain were increasing continuously as we move along the supply chain. The P&G experts called this phenomenon the "bullwhip effect", and it was proven that this phenomenon occurs in almost all the organizations whose products or services include a multi-level supply.

Distorted information from one end of the supply chain to the other end of the supply chain may lead to very damaging consequences. Many companies are looking for an efficient way of preventing the bullwhip effect, and in order to do so, they have to start with the basic considerations and understanding of its consequences, which may be a very complex task.

When the bullwhip effect occurs in the supply chains, and when the demand information along the supply chain is distorted, then the following are the undesired consequences:

- increase in inventories,
- poor forecast of future conditions,
- reduction or increase of delivery possibilities,
- loss of revenue,
- poor planning of the future capacities,
- passive transport and logistics,
- disturbances in the production schedule,
- low level of service,
- uncertain and expensive production,
- high costs of corrections (e. g. shipments, overtime, etc.).

Figure 2 shows graphically how the bullwhip effect occurs along the supply chain.

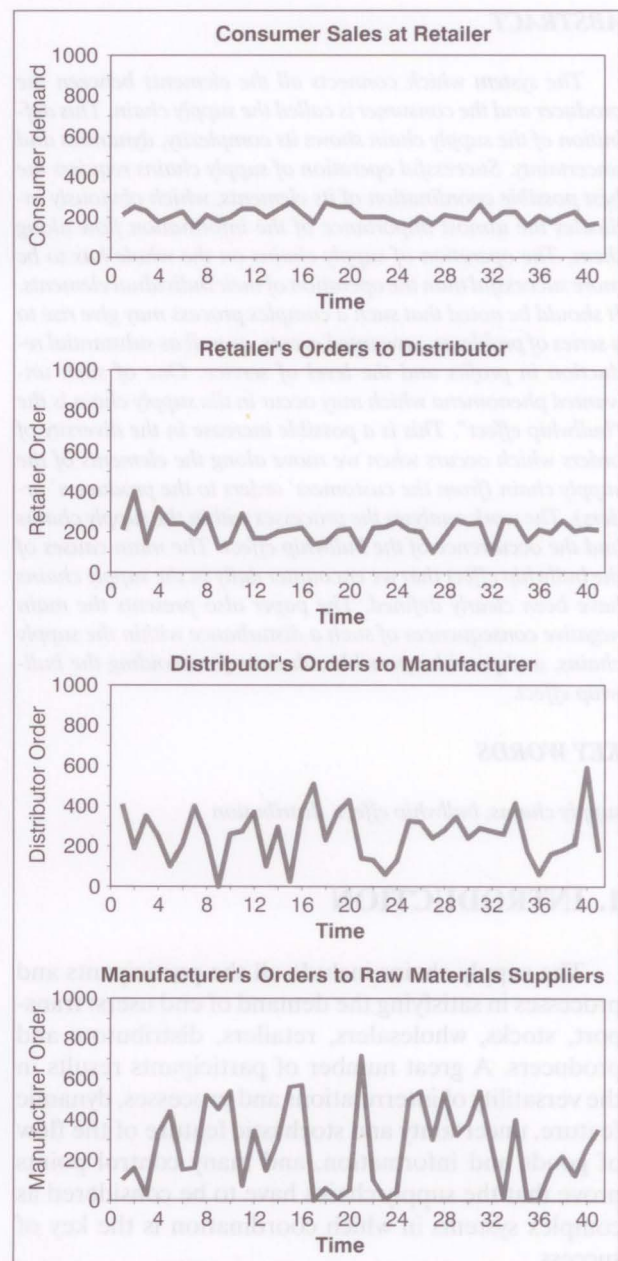


Figure 2 – Graphical presentation of bullwhip effect occurrence in the supply chain

3. WHAT CAUSES THE BULLWHIP EFFECT

3.1 "Beer game"

Maybe the best illustration of the bullwhip effect is the well-known "beer game". In the game, the participants (students, managers, experts, etc.) play the roles of the consumer, retailers, wholesalers and purchasers in the supply chain of beer purchase. The players mustn't communicate with each other and have to carry out orders based on the orders of the next player below them in the supply chain.

The order samples have a common denominator: *the variables of the subject above in the supply chain are always bigger than those that are lower in the supply chain*, this is a simple but strong illustration of a bullwhip effect. This increase of orders along the supply chain may be assigned to the irrational ordering by the players.

As opposed to this, one might say that the bullwhip effect is the consequence of rational behaviour of the players within the infrastructure of the supply chains. This essential difference shows that the companies that would like to control the bullwhip effect, should focus on the modification of the infrastructure of supply chains and related processes, rather than on the behaviour of subjects making the orders.

3.2 Causes of the bullwhip effect

Based on the research related to the bullwhip effect, four main causes may be identified:

1. updating of the demand forecasting;
2. grouping of orders;
3. price fluctuation;
4. re-distributions (rationing)

1. Updating of the demand forecasting

Each company in the supply chain plans the demand for its products, because of the production scheduling, capacity planning, inventories control, and raw material demand planning. Planning is usually based on the orders of the direct customers. The results of the "beer game" are consequences of several factors, such as perception and lack of confidence of the players.

When an order is made at the supply chain subject, the manager of the higher subject in the supply chain processes this information as the signal of the future demand. Based on this signal the manager rearranges the order according to the supplier. It may be concluded that such demand signal processing is the main reason for the occurrence of the bullwhip effect.

2. Grouping of orders

In the supply chain every company handles the orders using the data about the quantity of inventories. The orders are received but the companies do not order from their suppliers simultaneously. Often the received orders are grouped, and only then the order is proceeded to the supplier. Instead of frequent ordering, the companies make orders weekly, every two weeks or monthly. There are several reasons for the system of inventories based on the order cycles. Often the supplier cannot meet the requirements of frequent orders, because time and costs of order processing have to be real.

If, for instance, a company is considered that makes orders once a month, their supplier is faced by highly variable orders, so that once a month there is a leap in the demand, and after that there are no orders for one month. The mentioned example shows that periodical ordering increases the variability, and contributes to the occurrence of the bullwhip effect.

3. Price fluctuation

According to some European estimates, 80% of transactions between the producer and the distributor at grocery stores is done by in-advance purchasing of goods. It is precisely this in-advance payment that contributes to the price fluctuation on the market. The producers and distributors have periodically special actions, such as discounts, special offers, voucher shopping, etc. All these promotional actions result in price fluctuations, and increase in the costs of the supply chains.

What happens if in-advance payment becomes a standard? When the product price is low (due to promotional actions or discount), the customers buy it in larger quantities than they would need. When the price of the product returns to normal, the customers stop buying the product until the stock is empty. The result is a situation in which the shopping pattern does not reflect the consumption pattern, and in which the variations in the quantities of purchased products are much greater than the variations in the product consumption. The result of such a situation is the bullwhip effect.

4. Re-distributions (rationing)

If there is a situation in which the demand for a certain product is increased and the producer is not capable of responding to it at that moment, then follows the re-distribution or rationing (division of the product into smaller parts) of the product to their customers.

In case of a situation in which there is greater demand for a certain product and the producer is not capable of responding to it at that moment, then follows the re-distribution or rationing (division of the product into smaller parts) of the product to their custom-

ers. For instance, if the total purchase is only 50% of the total demand, all the customers will get 50% of what they had ordered. Having this in mind the customers overdo with their orders in order to get greater quantities of products.

Later, when the demand settles down, new orders will suddenly disappear, and the old orders will start to be cancelled. This example clearly shows the large variations of orders, which naturally results in the bullwhip effect.

4. MINIMIZING THE BULLWHIP EFFECT

For the minimization of the bullwhip effect it is necessary to define and understand the "forces" that stimulate customer demand planning, since these are the triggers of the order supplementation at various points in the supply chain. The most efficient way to mitigate oscillations caused by the bullwhip effect is for the distributors and suppliers to understand what makes the supply and demand work, and then to jointly work on the improvement of the quality of the exchanged information, as well as shortening of the actions throughout the supply chain.

We may say that in order to reduce the effects of the bullwhip effect, some or all of the following actions need to be undertaken:

- minimize the cycle from receiving the planned and actual information for consumption;
- establish real-time control of the actual demand for products, as precisely as possible;
- understand the demand for products at every level of the supply chain at the same time connecting the logistic service providers;
- increase the frequency and quality of information between the subjects in the supply chains;
- minimize or stop the "waiting" of information which result in the delay of the flow of goods;
- stop varying of the inventories, which cause demand lumps in supply chains;
- offer products at relatively acceptable prices in order to minimize the purchase of products at promotional discounts;
- identify and prevent the causes for reductions and cancellations in the customers' demand;
- allow retailers to control the inventories by planning the stocks in coordination with the consumers that project the end demand.

5. CONCLUSION

The supply chain connects the suppliers and the consumers during the entire process of production

and distribution, and as such requires control and coordination in which managers try to eliminate the uncertainties and negative consequences that may occur during the functioning of the supply chains.

One of the largest negative consequences that may occur in the supply chain is the bullwhip effect. This is an undesired occurrence of the quantity variability and the goods flows in the supply chains, as consequence of small variations in the demand of the end consumers. This phenomenon depends mainly on the fact that decisions are made based on the limited amount of information. These distorted information from one end of the supply chain to the other can result in very damaging consequences.

Companies can successfully withstand the bullwhip effect if they understand fully its main causes. Big companies implement new strategies that set new challenges: the integration of the new information system, defining of new organization connections, implementation of new incentives and management systems.

The decision made by the company is clear: *either let the bullwhip effect paralyse them or find ways to overcome it.*

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SAŽETAK

"BULLWHIP EFFECT" U OPSKRBNIM LANCIMA

Sustav koji povezuje sve elemente između proizvođača i potrošača nazivamo opskrbeni lanac. Iz takve definicije opskrbnog lanca može se uočiti njegova složenost, dinamičnost i neizvjesnost. Za uspješno djelovanje opskrbnih lanaca potrebno je što kvalitetnije koordinirati rad njihovih elemenata, pri čemu se jasno vidi da je protok informacija duž opskrbnih lanca presudan. Djelovanje opskrbnih lanca u cjelini mora biti uspješnije od djelovanja njihovih elemenata pojedinačno. Treba napomenuti da se u tako složenom procesu može javiti niz problema, neželjenih događaja, kao i znatno smanjenje profita i razine usluge. Jedan od nepoželjnih fenomena koji se može javiti u opskrbnim lancima je i efekt biča ("bullwhip efekt"). To je povećanje varijabilnosti narudžbi koji se javlja kada se pomičemo duž elemenata opskrbnog lanca (od narudžbi potrošača do narudžbi proizvođača). U radu se analiziraju procesi unutar opskrbnih lanaca, te pojava efekta biča. Jasno su definirani glavni uzroci efekta biča sa kojima se svakodnevno susrećemo u opskrbnim lancima. Navedene su i glavne negativne posljedice takovog poremećaja unutar opskrbnih lanaca, kao i moguća rješenja za izbjegavanje efekta biča.

KLJUČNE RIJEČI

opskrbeni lanci, efekt biča ("bullwhip effect"), distribucija

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