

## THE BULLWHIP EFFECT IN SUPPLY CHAIN

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**Abstract:** In a supply chain the variability of the orders received by the supplier can be greater than the demand variability. This phenomenon is named bullwhip effect. Some researchers are quantified the bullwhip by measuring the differences between observed variances in the different stages of the supply chain. The bullwhip effect refers to the phenomenon of amplification and distortion of demand in a supply chain. By eliminating or controlling this effect, it is possible to increase product profitability reducing useless costs such as stock-out and obsolescence costs. The bullwhip itself it is not a good index of the chain's performance, because it does not consider the oscillations that occur in the inventories, which also may affect the supply chain performance.

**Keywords:** bullwhip effect, supply chain, logistics

Predicting of demand is the significant tool in order the production planning and provisions, managing the surface or creating levels of personalized services. Predicting demand by many technologies is relying on earlier data and their importance is setting up from patterns utilized heretofore earlier of demand for near future. Of values predicted with regard to high responsiveness for of the ones most current, this approach is obtaining in general high (low) values of demand predicted in accordance to periods high (low) of demand. It is being transferred by demand of clients to wholesalers, distributors or producers in the form of the retail order which is current demand for partners of the chain of supplies of the higher mark at the same time. Forecasts of demand are rarely in practice when thorough and what's more they are still refer to the poor quality higher marks in the chain of supplies. In the majority of chains of supplies, individual participants in the chain are trying to rationalize sizes of one's orders in accordance to economic decisions, what the distortion of real demand of clients is being created, through as well as bad redirection of demand at members of the chain of supplies from upper of its levels. Promotions and price hesitation also have influence for distorting demand [2., 12.].

The need to predict demand is increasing errors by chances to perform on every level of the chain of supplies in forecasts - called the bullwhip effect (BWE) this way - for the whole supply chain. The seeming effect is creating it of double predicting [8]. And therefore it is so very important determining the operating system correctly of predicting of demand which the bullwhip effect will limit.

The regular, simple model of supply chain and its flows consist such participants as: supplier, producer, intermediary or distributor, retailer and customer, all with products and information flows. This structure is presented below on figure 1.

So taking into consideration the above mentioned model it is possible to do the graphical presentation of the bullwhip effect in supply chain especially with pressure on its formation.

Based on Figure 1, Figure 2 is presenting how bullwhip effect is establishing itself in supply chain.

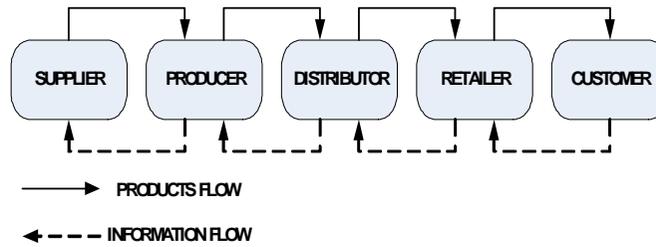


Figure 1. Basic model of supply chain and its flows.

Source: Own elaboration based on [13.].

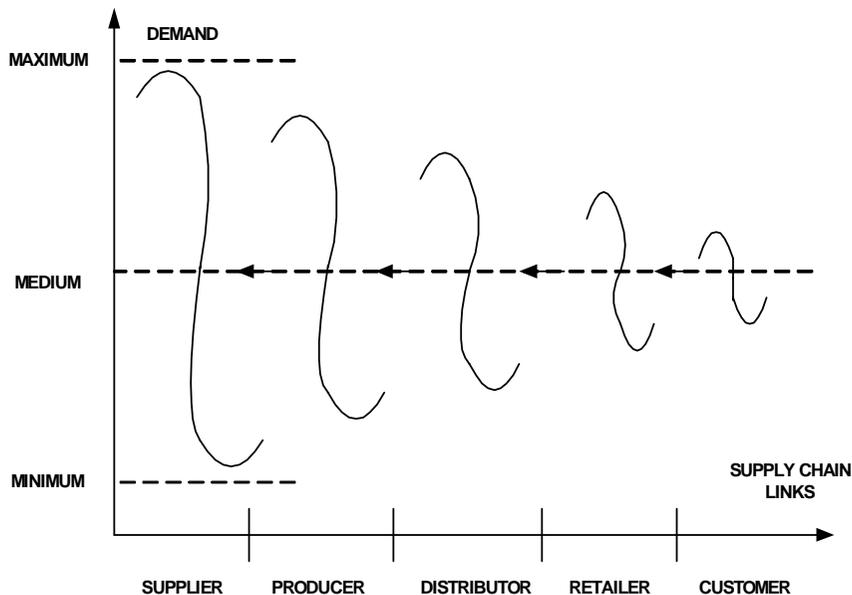


Figure 2. The bullwhip effect in supply chain.

Source: Own elaboration based on [13.].

The bullwhip effect is one of key areas managed in applications of administration with chains of supplies of examinations. It is representing the phenomenon where orders are trending to deliverers for being more diversified than what is being sold to buyers but consumer demand is deformed [9.]. This distortion of demand is being spread too for higher stages in the amplified form. High levels of provisions and the weak level of using of the client are posing standard symptoms of the bullwhip effect in the chain of supplies. Keeping production costs and provisions stable and the increase in main times are proving it additionally while margins of the profit and availability of products are falling [4.].

Presented empirical examinations carried out in literature of the subject [10.] is resulting that the total elimination of the bullwhip effect is able to raise product profitability of about 10%-20%, however decrease in the bullwhip effect is making the possible profitability height of about 5%-10%. Linking the elimination or decrease in the bullwhip effect to the reduction of the other property (e.g. of seasonality) is possible to obtain profitability higher of about 15%-30% in dependence on the specificity of the business environment.

The bullwhip effect appeared for the first time in literature as the subject in 1961 year [5.]. The author of the study noticed this effect of batches executed at bargain of simulation analyses. He determined this problem initially with name of increasing of demand. The problem of the bullwhip effect is resulting from the system according to it along with its policy, the organizational structure and delays in flows of materials and information, rather than is coming from external sources. The bullwhip effect is defined as the effect of lack of the information exchange between components of the chain of supplies and of occurring of non-linear interactions which they are causing for the difficulty in administration with them. Other author in 1989 year [14.] stated that it was lack of understanding in order giving support to the desire from the side of other participants in the supply chain and the irrational reaction is causing the rise of the bullwhip effect from the side of persons taking decisions up in the made system. Since people have problems with analyzing impact of the decision about to order the system for the complexity and temporary delays between ordering and with receiving, the insertion of trainings would be necessary from the range of the bullwhip effect for managers. From the other side the bullwhip effect is witnessing one way or another even if all participants in the supply chain are behaving in the optimal way unless the supply chain will be rebuilt along with various strategic with mutual relations - the bullwhip effect is able then not to occur [8.].

The bullwhip effect was determined for the simple chain containing the one retailer of supplies and the one producer in the other study [3.], as applying for the correlation of the baulk with current demand but its earlier values while the retailer is fulfilling orders relying only on earlier demand. What's more, delivering size of the bullwhip effect to information to every level of the supply chain about consumer data perhaps to lessen but it will be existing still if information is centralized at every stage about demand.

From examinations it is resulting that the bullwhip effect is resulting from four factors chiefly [11., 13.]:

1. Predicting of demand; predicting of demand by every participant in the supply chain. Forecasts of demand are being elaborated in every link of the supply chain on the basis of historic data and information about changes taking planned publicity drives or other action shaping final consumers' demand into consideration of demand. These forecasts are being modified after receiving orders from clients. Every company is handling other output in reality that is utilizing distorted information about market demand and it is taking supply decisions up on their basis. The long supply chain is amplifying the bullwhip effect with many intermediate links because it is occurring on every level increasing unstable demand, moreover the time of the information transmission and the time of material flows are being prolonged which means the longer response time for changes of demand on the retail market. The decision about liquidation of the part of intermediate links has to be subjected to the detailed analysis comparing the added value to expenses by each agents of their functioning. It is able as a result of the reduction of unprofitable links the new supply chain to rise.
2. Grouping of orders; assembling orders and maintaining provisions are managed according to various principles. The policy depends on making of orders from internal procedures of companies. It often relies on grouping orders and periodic ordering of big parties of commodities. Of reasons for such a procedure perhaps to be a lot of: high expenses of the study and concatenations of the order, transport savings at full transport, discounts and rebates given by deliverers at the purchase of big parties of commodities and dictating the order to size by minimal deliverers, but also policy of the loaning business (e.g. the payment for commodities makes from the end of the month which, they were bought, in after 30 days clients wait with the concatenation of the order to the beginning of the next month). It is causing with the

other person applying the accounting period to pushing out of orders by sales reps of the principle towards the end to realize the assumed sales plan. Such activating of sale is working in abrupt influx of orders at the same time, when demand is minimal through the rest of the period. It means this claiming by the majority of the period of heavy stocks and difficulties with in operating orders at the moment of the plurality of demand. Assembling orders by various principles and of completing provisions and rational decisions are managing managers to the fact that the order isn't bringing for information about default demand but about demand from before a few days or even a dozen or so weeks, corrected for necessary size to the completion of provisions.

3. Hesitation of prices; manipulating of prices. Deliverers are offering various promotions for customers periodically in the form of price or quantitative discounts, rebates, coupons, profitable dates of payment which price fluctuations are calling. Companies are reacting to these offers as a rule ordering, without regard to demand, big quantities of products during the promotion. They are assembling the next order from exhausting at the moment oneself of provisions or during the next promotion. It is managing to big changes of purchases which aren't reflecting actual demand reported by lower levels in the supply chain. It is being estimated, that 80% of the transaction refers to purchases between producers but with distributors in the food branch for the future because of the profitable price offer.
4. The rationing and deficits (lack); the rationing and lack of products. When demand reported by clients is exceeding the supply (e.g. within a period of the promotion, in front of expected with the price increase or the change for commodities of taxes and excises), the producer is rationing products that is the part of everyone is realizing orders in dependence on the level of provisions, e.g., if the supply is providing 70% clients are obtaining it out of demand 70% of what they reordered. The clients aware of this procedure, wanting to obtain necessary quantities of commodities which are overstating orders. When demand is stabilizing the part of orders, is being withdrawn at the same time orders are stopping flowing in. The image is effacing it about real for forming of demand, about the actual level of provisions in the whole supply chain and is managing companies in the field of production programs and the allocation and resources centres for taking invalid decisions up by managers. It has this huge importance when entering new products into the market. It is hard for the producer to reassess or demand for novelties is resulting from consumers' interest whether it is the consequence of creating provisions in distribution channels (effect of the fill the supply chain).

It is necessary here to notice, that distorting information about demand is also occurring inside companies entering to the composition of the logistic supply chain as a result of their internal policy and procedures. Phenomena are being visited to main reasons for it [15.]:

1. Taking rational decisions up by managers within the confines of their functional department instead of the department of production is aiming at producing long batches from the point of seeing the company and the whole supply chain, e.g. in order to reach the effect of the scale, is emphasizing in turn of cannons of using of the client for maintaining the high level of provisions to ensure the determined level of using of the client;
2. Predicting within the confines of each departments instead of collecting at the level of the company and a lot of places of decisions having impact of the forecast on execution; manipulating of the forecast of demand of purposes assumed in order reaching, e.g. of sale;

3. Low level of managers' knowledge about the bullwhip effect and about its influence on administration with supply chain;
4. Internal procedures of the company which data are distorting about demand, e.g. which minimal size of the order fitted together by distribution centres and the factory unit, minimal production volumes;
5. Minimizing provisions by the politician in order limiting expenses generated by them in the company; demand for resultant products is supposed as a result of changes of demand to be provided thanks to deliverers' fast reaction rather than behind means of provisions of safety; with effect of the one is maintaining them by transferring of the responsibility for provisions and expenses for deliverers.

Somewhat otherwise reasons of rising the bullwhip effect is formulating the author of the other study [9.], who sources of rising this effect is looking for in:

1. processing of demand-induced signals;
2. non-zero main time;
3. grouping of orders;
4. deficits and defects in supplies;
5. price changes.

Taking under is being spent by above-mentioned reasons for the most remark on the remark for predicting of demand. This reason is most often reinspected with the usage of various methods and technologies, as well as models in order predicting the explanation for influence of demand for the bullwhip effect and at the same time for managing the supply chain [6.].

It is possible to infer from analyzing factors contributing to rising of the bullwhip effect, grasping it in general - this effect is the effect of the bad flow of information in the chain of supplies. Enumerated in literature many tolerating possibilities are for reducing it. For instance three various options are possible whom the usage will reduce in the supply chain or almost will preclude the bullwhip effect [1.]:

1. change of the design of the physical process (e.g. the reduction of the main time, the elimination of the channel in the supply chain);
2. change of the design of information channels (e.g. delivering data to customers about demand through the supply chain);
3. change of the design of the decision process (e.g. utilizing various rules for completing of provisions).

Also, it is possible to enter 10 principles being able to assist the reduction of the bullwhip effect [6.]:

1. Control system principle: There is a need to select the most appropriate control system best suited to achieving user targets. In turn this will necessitate accessing important supply chain "states" thus taking unnecessary guesswork out of the system;
2. Time compression principle: Every activity in the chain should be undertaken in the minimum time needed to achieve task goals. In practice this means removing non-value added time or "muda" from the system. It also means delivering on time what is actually required i.e. this principle covers process capability;
3. Information transparency principle: Up-to-the minute data free of "noise" and "bias" should be accessed by all "players" in the system. This simultaneously removes information delays and "double-guessing" other "players". Because inventories, WIP, flow rates, and orders are now visible throughout the chain, holistic control by a suitable DSS is now enabled;

4. Echelon elimination principle: There should be the minimum number of echelons appropriate to the goals of the supply chain. The aim is to have not only the optimum level of inventories (maybe in some instances actually zero) but to have these minimum stocks in the right place at the right time;
5. Synchronization principle: In some simulations all events are synchronized so that orders and deliveries are visible at discrete points in time. Some other showed by reference to multiple customers working on re-order principles that this produced an emphatic bullwhip effect subsequently eliminated by continuous ordering synchronized throughout the chain;
6. Multiplier principle: There can be situations where orders directly multiply in a knock-on effect, usually between product manufacturers and their capital equipment suppliers. So if a product manufacturer replaced all its machine tools on a 10 year cycle, it might choose to increase planned capacity by 10% in 1 year, leading to its machine tool orders being doubled, a “multiplier” of 10 to 1;
7. Demand forecast principle: Forecasts may well be a problem simply because they are so rarely right. But attempts to improve the situation by building in safety factors and trend detection capability may result in bullwhip generation. Furthermore demand forecasts need to cope with such phenomenon as “product substitution” where what is actually available is sold in place of stock-out items;
8. Order batching principle: Time phased aggregation of orders lead to “lumpy” deliveries, and hence come back around the ordering loop as “lumpy” orders, which is a certain cause of bullwhip;
9. Price fluctuation principle: Marketing programs may deliberately be designed to empty over-full pipelines. As it has been demonstrated, this effect may cause a backlash by over-ordering so as to take advantage of discounts on offer. When the retailer has enough stock, their orders drop to zero in a typical boom-and-bust scenario;
10. Gaming principle: As it has been described in an actual (or perceived) shortage situation, there will be orders placed to “hedge” against unpredictable supply. Both suppliers and customers may be involved in this game, followed by double-guessing of the form that X has ordered 1000, but it seems like he only needs 400 followed by that Y is slow with his deliveries so if the real need is 500 it is better to order 1200 just in case.

So it seems that there is a lot of possibilities to reduce and minimize of existing bullwhip effect in supply chain. Bullwhip has a long tradition for causing disruptions and massive over-swings and under-swings in demand. The former results in quite unnecessary ramping up of production (usually tried at great speed with the generation of corresponding inefficiencies), and the latter necessitates much pain via paid idle time and possible redundancies. The on-costs incurred include “learning effects” for new labour on the upswing, and lay-off costs on the downswing. Because of this cyclical behaviour (well-known in economic circles as the boom-and-bust scenario), the stocks will also fluctuate out-of-phase with demand. So again on the upswing, there will be stock-outs, whilst on the downswing there will be excess stock with a tendency to incur obsolescence and to damage during excessive storage periods. So business is lost because the products are not available when required, and when they are available they are at a higher cost than need be [6.]. Causes of bullwhip effect are in part due to problems in value-added processes, supplier difficulties, demand volatility, and control processes. A way forward is to re-engineer the supply chain to systematically remove all avoidable causes of uncertainty. This requires the effective application of business systems engineering principles involving technical, cultural, organizational, and financial aspects of the project. It is the good idea to use here some

programs which are smoothing material flow, smoothing and making transparent information flow, time compression of all processes, holistic controls and the abolition of all interfaces. The consequence might be a movement away from traditional, adversarial operations, towards the minimal bullwhip seamless supply chain scenario.

Also there might be used some IT solutions to improve supply chain competitiveness. This includes avoiding bullwhip on-costs by using proven designs to ensure smooth material flow as needed to satisfy the true demands of the marketplace. The present literature study shows that the first step must always be to implement the time compression principle [7.] and hence reduce all lead times to their optimum value. It is also axiomatic that these new reduced targets must be consistently achieved if uncertainty is to be reduced.

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