

Bullwhip Effect - The Dilemma in SCM

*Garima Gupta **Shaili Gupta

The Fundamental challenge today for supply chains is to achieve co-ordination in spite of multiple ownership and increased productivity. Many firms have observed the Bullwhip Effect (Forrester effect), in which fluctuations in orders increases as they move up the supply chain from retailers to wholesalers to manufacturers to suppliers. The bullwhip effect results in a loss of supply chain coordination. Supply chain experts have recognized that the Bullwhip Effect is a problem in forecast-driven supply chains. The major cause of this effect is lack of information sharing, operational inefficiencies leading to large replenishment lead times & large lots and a lack of trust that makes any effort toward coordination difficult. Thus the manager by sharing of sales information and collaborative forecasting, planning & implementation of single point control of replenishment, improving operations to reduce lead times & lot sizes and building of trust & strategic partnerships within the supply chain can reduce this dilemma. The paper discussed how BULLWHIP EFFECT emerges, how it results in poor performance and the managerial actions to be taken to wipe out it.

Introduction

Supply chain co-ordination requires all stages to take actions that maximize total supply chain profits. A lack of co-ordination results if different stages focus on offering their local objectives or if information is distorted as it moves across the supply chain. Today, supply chain often consists of stages with hundreds of different owners. E.g. Ford Motor Co. has thousand of suppliers, from Good Year to Motorola and each of these suppliers has several other suppliers in turn. The fundamental challenge today for supply chain is to achieve co-ordination in spite of multiple ownership & increased product variety. So, this paper is an attempt to study the Bullwhip effect that comes while maintaining co-ordination in supply chain.

The phenomenon in which the fluctuations in orders increases as one moves up the supply chain from retailers to wholesalers to manufacturers to suppliers is referred to as the Bullwhip Effect as shown in figure 1. It was first discovered by Jay Forrester that variations in demand increases as it moves up the supply chain from customer to final supplier. The Bullwhip effect distorts demand

information within the supply chain, with different stages having very different estimate of what demand looks like. The result is loss of supply chain co-ordination.

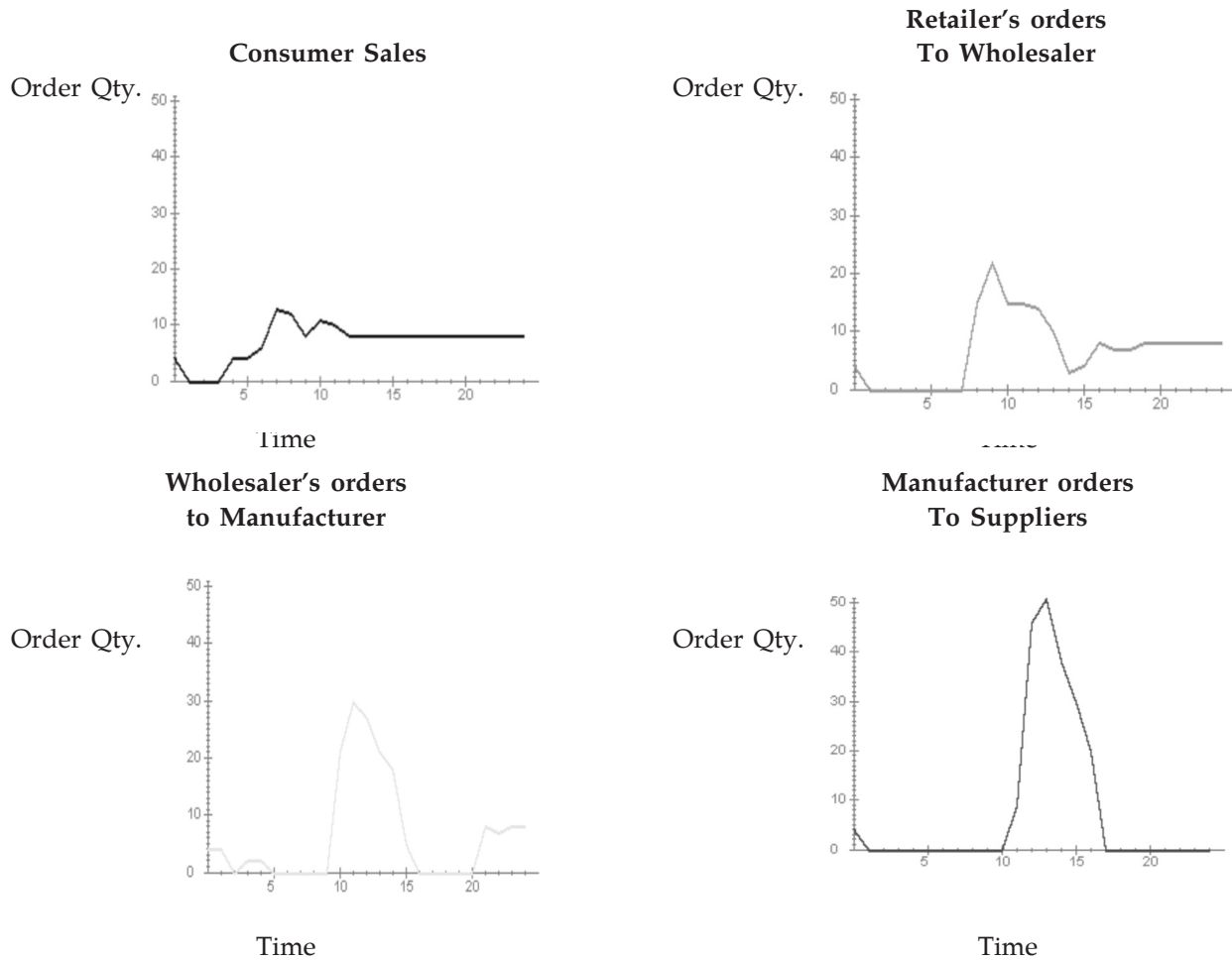
P & G which was stable demand product first observed the Bullwhip effect in supply chain for pampers diapers. The company found that raw material orders from P & G to its suppliers fluctuated significantly over time. Further down the chain, when sales at retail stores were studied, it was found the fluctuations, though present, were small. So it is logical to assume here that consumers of diapers at the last stage of supply chain demanded them at a steady rate.

Although consumption was stable, orders for raw material were highly variable and increasing costs were making it difficult for supply to match demand. Further HP (Hewlett Packard) also found that the fluctuations in orders increase significantly for its product printer as it moved from resellers up the supply chain to printer division to the integrated circuit division. Studies of apparel & grocery industry have shown similar phenomenon as per the literature.

*Assistant Professor, Jaipuria Institute of Management Studies, Ghaziabad

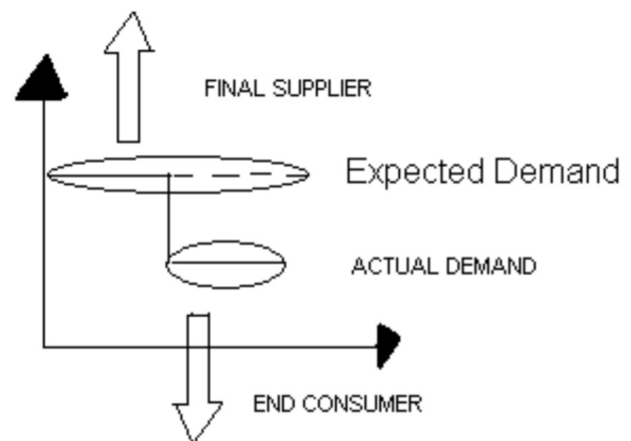
**Lecturer, T.I.M.T, Yamuna Nagar

Figure 1: The bullwhip effect - Increasing demand variation in a supply chain



Source: Joerg Nienhaus, Arne Ziegenbein, Christoph Duijts "How human behaviour amplifies the bullwhip effect -a study based on the beer distribution game online"

As supply chain mgt. is related with managing supply of goods matching to demand created at each and every level of chain moving from down to upward. Sometimes demand may deviate from the forecasted in the chain causing the whole management to end up in mismanagement. Hereby, any fluctuations in demand at one level magnifies the demands of higher level and finally causing rippled effect at the top and which is known to be as Bullwhip effect. It is also called as Whiplash effect. Bullwhip effect occurs as orders moves from down to upstream participants of supply chain with different forecasts of good causing variation at every level to be amplified at next higher level and finally magnified effect of these oscillations of demand forecast resulting in either piles of inventory or stock outs. So it is all about the variability in demand.



It can be calculated as (used by Lixin Miao, Xiongbo Guo, and Zhiwei Miao):

$$\frac{\text{Var}(Q)}{\text{Var}(D)} \geq 1 + \frac{2L}{p} + \frac{2L^2}{p^2}$$

where, D = demand received by retailer
 Q = quantity ordered by retailer
 L = lead time
 P = number of data used by retailer to forecast demand

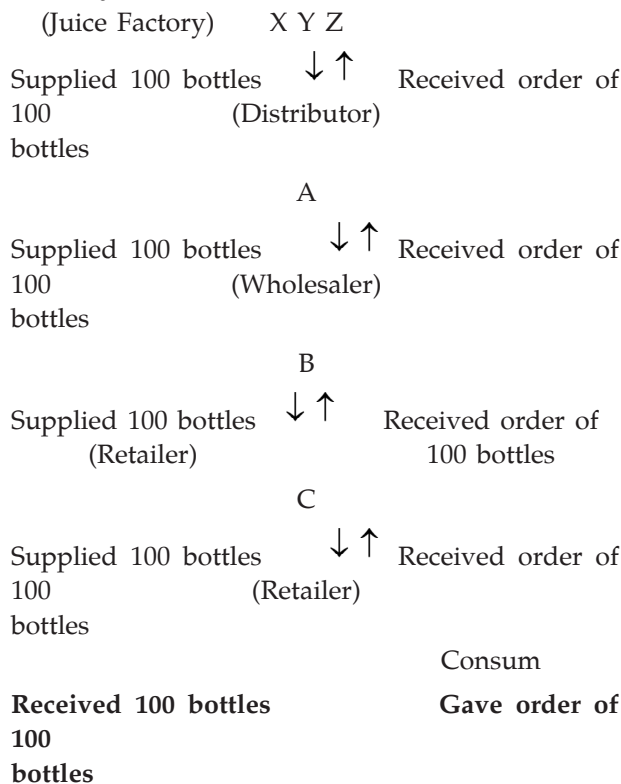
Let us understand it with a fictitious study:
 Let's assume there are 4 parties in the Supply Chain of a bottled Juice Company XYZ

Assumptions:

There are only 4 parties in the Supply Chain.

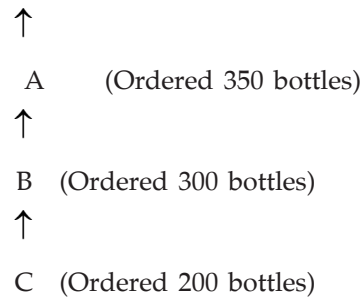
- 1) Product is perishable.
- 2) There is no exchange of information except the order placed at different stages of supply chain. Everybody was forecasting of his own.
- 3) Supply is equal to Demand only.
- 4) Planned promotion at retailer is of short level.

Supply Chain Of XYZ



SC After retailer's planed promotion leading to short duration increase in demand

ABC (Mfd. 400 bottles)



Output = 400 bottles

Final Consumption = 200 bottles

Unused stocks = 200 bottles

Thus actual consumption was of 200 but produced 400 leading to 200 as total waste because of goods perishability.

Explanation of above situation

As the final consumer consumes only 100 bottles of juices daily & thus Retailer 'C' always orders 100 bottles to the wholesaler 'B' & thus wholesaler also orders only 100 bottles to distributor and finally distributor orders 100 bottles to Factory and Factory 'XYZ' produces 100 bottles daily. One day, Retailer planned a small promotional Campaign & in regard to that he expected his sales to be increased to 200 bottles and thus 'C' ordered 200 bottles to 'B'. After getting increased order 'B' expected increased demand in market & by adding to his intuitions 'B' ordered 300 bottles to 'A' for keeping as safety stock. 'A' also after picking the order expected boost in sales and ordered 350 bottles to prevent himself from stock out to XYZ. XYZ also didn't have any other information from down the chain except the increased order. XYZ added to the order his own level of intuitions to 400 as safety stock. But finally when it came to consumption it was only 200 which was also short lived thereby causing loss of 200 bottles of juices to be as waste. This amplified impact is finally called as Bullwhip effect.

MIT's Beer Game to detect Bullwhip Effect

Beer distribution game has its origin in the Systems Dynamics Group at (MIT) Massachusetts Institute of Technology in 1960s developed by a

group of professors, which is a way to demonstrate the bullwhip effect by simulating supply chain. Minimum 4 players are required for this game i.e. supplier, wholesaler, distributor, retailer with intense competition. This game requires 1.5 hour to play and lastly 1.5 hour in debriefing of the whole result of the game. Communication is not done in between any of the party and the motive is to have minimum expenditure on back ordering and piling of inventory. The parties hereby supply the beer cases to meet customer demand. Parties in chain feel frustrated and confused as they don't have any communication in between each other trying to figure out the culprit. They are not able to figure out that is there anyone who is not able to understand the pattern of demand or assume that demand is having erratic pattern and adding their own beliefs to it. This whole thing is done during 1.5 hrs of game. Lastly, in debriefing session it is told that such behaviors are common in real life chains & all this finally leads to occurrence of Bullwhip effect.

BEER GAME

Players	Minimum 4 players & multiple teams
Age range	Graduate students and members of business mgt.
Set Up time	10-20 minutes
Playing time	1.5 hrs plus another 1.5 hrs at last for debriefing
Random chance	None

Why Bullwhip effect emerges?

Major reasons for emergence of Bullwhip effect in supply chain management are excessive replenishment lead times and excessive delay in information sharing from bottom to top else are the behavioral patterns of the parties of supply chain giving birth to bullwhip effect. Further the reasons for Bullwhip Effect are discussed in details:

Incentive Reason: It refers to situations in which incentives offered to different stages or participants in a supply chain leads to actions that increased variability & reduce total supply chain profits.

Sales Force Incentives: Improperly structured sales Force incentives are significantly obstacles to co-ordination in the supply chain. As sales force

incentives increases by amount of goods, they increase selling to the distributors & retailers. So, they offer discounts to them at the end of evaluation period thereby increasing the sales to middleman without increase to the final consume. Finally it results in a jump in orders towards the end of evaluation period followed by very few orders at the beginning of the next evaluation period thereby causing extreme demand variability.

Forecasting based on orders, not customer demand:

Each stage views its demand to be the number of orders received and thus forecast is based on this information. In this scenario, a small change in customer demand becomes magnified as it moves up the supply chain in the form of customer orders. For example retailers may interpret the random increase in demand from customer as growth trend or vice-versa and thus anticipating such, will place order more than the observed increase to wholesaler. In turn wholesaler not interpreting the increase correctly and may even place a large order with manufacturer and as we go up further. The order size will be magnified leading to demand variability.

Lack of information sharing: The Lack of information sharing stages of the supply chain magnifies the Bullwhip Effect. A retailer in planned promotion may order increased sizes to manufacturer but manufacturer without being aware of may start producing high inventory and after the retailer has furnished his promotion may return back to normal leading to high inventories tied up with manufacturer leading to variability in orders.

Large Replenishment lead times: The Bullwhip Effect is magnified if replenishment lead times between stages are long. As retailer faces a lead time of two weeks it will incorporate the (misinterpreted random increase) growth over two weeks when placing the order.

Lot size based quantity discounts: Lot size based quantity discounts increase. The lot size of orders placed within the supply chain. The resulting large lots magnify the bullwhip effect within the supply chain.

Price fluctuations: Trade promotions & other short term discounts offered by a manufacturer result in forward offering in which a wholesaler or retailer purchases large lots during the discounting period

to cover demand during future periods. Forward buying results in large orders during the promotion period followed by very small orders after that. Each stage of supply chain views its actions locally and is unable to see the impact of its actions on other stages and react to current local situation rather than to identify the root causes.

Aftermaths of bullwhip effect

Manufacturing cost: The Bullwhip effect increases cost in the supply chain. As the company can respond to the increased variability by either building across capacity or holding excess inventory which in turn increase the manufacturing cost per unit of product.

Inventory cost: Bullwhip effect increases inventory cost in supply chain. To handle the increased variability in demand, co. may have to carry more inventory and thus increased warehousing cost and thus inventory cost.

Replenishment lead times: Bullwhip effect increases the replenishment lead times in the supply chain. The increased variability is a result of Bullwhip effect; it is much more difficult compared with a situation with constant level demand. This results in higher replenishment lead times with in the supply chain.

Transportation cost: Transportation cost is correlated with orders being filled. As a result of Bullwhip effect, transportation requirement will also fluctuate significantly over time. This has the impact of raising transportation cost because surplus transportation capacity needs to be maintained to cover high demand periods.

Level of product availability: The Bullwhip effect impair the level of product availability and results in more stock outs within the supply chain. The large fluctuations in orders make it less likely that company. will be able to supply all distributor and retailer order on time and thus resulting in loss of sales for supply chain.

Compromise with Quality: Due to unexpected orders then planned in supply chain management, companies may sometimes behave casually towards quality in order to meet placed orders.

Relationship across the Supply Chain: The Bullwhip effect negatively affects performance at

every stage and thus hurts the relationship between different stages of supply chain. There is tendency to assign blame to the other stages of the supply chain because people involved at each stage feel they are doing the best they can. It leads to loss of thrust & makes any potential co-ordination effort more difficult.

So, the Bullwhip effect reduces the profitability of supply chain by making it more expensive to provide a given level of product availability.

Actions to conquer bullwhip effect

A manager may take following actions to moderate the Bullwhip effect and may achieve co-ordination in the supply chain as this is an important issue in supply chain to be focused:-

Aligning goals & incentives:

Managers can improve co-ordination within supply chain by aligning goals & incentives such that every participant in supply chain actively works to maximize total supply chain profits. For e.g. Sales force incentives based on sales over a rolling horizon, to link incentives for the sales staff to sell through by the retailer rather than sell in to the retailer.

Improving information accuracy:

By improving the accuracy of information available to different stages in the supply chain can moderate the Bullwhip effect. e.g. sharing point of sale (POS) data across the chain so, that all the stages in chain will respond to same change in customer demand instead of varying forecasts. P & G has connected many retailers to share demand data, Wal-Mart shares POS data with its suppliers, different stages of Supply Chain planning jointly.

Use technology to improve connectivity in Supply Chain:

By reducing the replenishment lead times managers can decrease the uncertainty of demand during lead time by using EDI (Electronic Data Interchange) and other electronic forms of communication. Wal-Mart has successfully used many of these approaches to reduce lead times. It was said in National Textile

Center Annual Report-Nov.2004 that in the best replenishment scenario Bullwhip effect remains to only 50%.

Designing pricing strategies to stabilize orders:

Managers can dampen the Bullwhip effect by eliminating promotions and charging on every day low pricing (EDLP). The elimination of promotions removes forward buying by retailers and results in orders that match customer demand. P&G have implemented EDLP to dampen the Bullwhip effect.

Collaborative Planning, Forecasting and replenishment (CPFR)

To crack the bullwhip effect no. of companies are opting for CPFR whereby all the parties plan, forecast and replenish for the supply of products jointly. As distortion of demand occurs because of different forecasts of demand, replenishment times of stocks etc. by every level of supply chain. So if CPFR is done i.e. jointly planning for the demand etc, there will be no amplifications of demand at any level. For having this there is obviously some requirement of a media of communication in between the parties.

The companies like Wal-Mart are able to cope with this situation of Bullwhip effect by adopting healthy form of communication through out the Supply Chain or we can say a proper POS information sharing. This is also called as "Kan-Ban" which is a Japanese technique whereby levels of safety stocks are reduced to maximum extent.

Conclusion

The Bullwhip effect occurs as the supply chain of any firm develops. But it can't be solved by

conventional style of management. Even the most modern styles of management with all its bells and chimes, can't automatically wipe out the Bullwhip effect. As explained earlier, it is a problem occurring in the demand management process of a company with very broad repercussions as it includes policies, measurement systems, practices and sometimes also the core of organization's values and beliefs. This demand fluctuation magnifies as the demand pass further up the supply chain. However the most effective way to solve out is the understanding of customer and suppliers that what derives demand and supply patterns and then working together to wipe out Bullwhip effect. Further a strategic alliance between retailer and supplier is a good way to weaken this effect.

References

1. Lee H L, V Padmanabhan & S Whang (1997), "Information distortion in a supply chain: The bullwhip effect", *Operations Research/Management Science*, Vol 37, 3, pp 289-292
2. "Supply Chain Management Improving Efficiency", *Synergy-ITS Ghaziabad*, Vol4, No2, July06
3. Gwenny R Dirk, P Van D and Taco V (2005), "The beer game revisited: relating risk-taking behaviour and bullwhip effect" *Harvard Business Review* 36 (4) 37-66
4. Joerg Nienhaus, Arne Ziegenbein, Christoph Duijts "How human behaviour amplifies the bullwhip effect -a study based on the beer distribution game online", *Vikalpa*, Vol 18, No3
5. Burt Dobler & Starling, "World Class Supply Chain Management", *Tata Mc Graw-Hill*, New Delhi
6. John T Mentzer, "Supply Chain Management" *Response Books Publication*, New Delhi
7. Rahul V Atekar, "Supply Chain Management" *Prentice Hall Pvt. Ltd.*, New Delhi
8. Chopra S, Meindly P, "Supply Chain Management" *Pearson Education*, New Delhi