The Bullwhip Effect in Supply Chains: Causes and Remedies

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ABSTRACT

The increasingly flattening world is constantly evolving and impacting the way of doing business. Supply Chains have become global, complex and dynamic. The success of a company hinges on developing innovative supply chains strategies that helps to win in turns and make money from information while driving continuous improvements. The objective of supply chain management is to provide a high velocity flow of high quality, relevant information that will enable suppliers to provide an interrupted and precisely timed flow of materials to customers. However, unplanned demand oscillations, including those caused by stock outs, in the supply chain execution process create distortions which can wreak havoc up and down the supply chain. There are numerous causes often in combination that will cause these supply chain distortions to start what has become known as the "Bullwhip Effect". The purpose of this study is to find out a detailed solution of the causes of bullwhip effect.

Keywords: Supply Chain Management, Bullwhip effect

1. INTRODUCTION

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers and customers themselves. Within each organization, such as manufacturers, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but not are limited to new product development, marketing, operations, distribution, finance, and customer service.

A supply chain is dynamic and involves the constant flow of information, product, and funds between different stages.

The primary purposes from the existence of any supply chain is to satisfy customer needs in the process generating profits for itself. Supply chain activities begin with customer order and end when a satisfied customer has paid for his or her purchase.

1.1 Strategy of Supply Chain Management

In the ancient Greek fable about the tortoise and the hare the speedy and overconfident rabbit fell asleep on the job, while the "slow and steady" turtle won the race. That may have been true in Aesop's time, but in today's demanding business environment, "slow and steady" won't get you out of the starting gate, let alone win any races. Managers these days recognize that getting product to faster than the competition will improve a company's competitive position. To remain competitive, companies must seek new solution to important supply chain management issues such as modal analysis, supply chain management, load planning, route planning and distribution network design. Companies must face corporate challenges that impact Supply Chain Management such as reengineering globalization and outsourcing.

Why is it so important for companies to get products to their customer quickly? Faster product availability is key to increasing sales, says R. Michael Donovan of Natick, Mass.[1], a management consultant specializing in manufacturing and information systems. "There's substantial profit advantage for the extra time that you are in the market and your competitor is not," he says. "If you can be there first, you are likely to get more orders and more market share." The ability to deliver a product fester also can make or break a sale. If two alternative (products) appear to be equal and one is immediately available and other will be available in a week which would you choose? Clearly "*Supply Chain Management has an important role to play in moving goods more quickly to their destination"*

To protect market share and ensure survival companies have to meet future customer demand. A forecasting error can lead to inability to supply which not only results in loss of sale at the moment in time but may impact future sales due to a consumer loss of confidence. Forecasting is a productive process which by its very nature carries an element of uncertainty. However forecasting accuracy can be improved by reducing the uncertainty experienced within the supply chain especially via lead time reduction. It is clear that companies who understand and cope with uncertainty can optimize their forecasting potential and are in better position to produce internationally competitive bottom line performance.

The companies who design business strategies which acknowledge the presence of uncertainty and provide mechanisms for pro-actively tackling it are rewarded by an opportunity to enable best practice ahead of competitors whose response are purely reactive.

Much uncertainty is system induced and magnified by the 'Bullwhip effect" as opposed to being introduced by the marketplace. Hence the best way to cope with uncertainty is to work hard to reduce it. The ultimate goal in our approach. Is the Seamless Supply Chain (SSC) wherein all

players “think and act as one”. Thus the SSC obtains a greater market share to the benefit of all the “player” within the chain.

2. LITERATURE REVIEW

Lee et al. (2004) [2] mentioned that Forrester was the first person who documented the phenomenon of bullwhip effect, but the term was not coined by him. As per O’Donnell, Magure, McIvor and Humphreys (2006), [3] Forrester studied the dynamic behavior of simple linear supply chains and presented a practical demonstration of how various types of business policy create disturbance and he stated that random meaningless sales fluctuations could be converted by the system into annual or seasonal production cycles.

The term “bullwhip effect” was coined by Procter & Gamble when researchers studied the demand fluctuations for pampers. If there is no proper channel of information passage between the players in a supply chain (retailers, whole sellers, distributors, and manufacturers), this leads to inefficiency like excessive inventories, quality problems, higher raw material costs, overtime expenses, and shipping costs (Lee et al. 1997a, b [4]).

Classic management techniques are widely employed to reduce the bullwhip effect in supply chains. In the JIT system, materials are moved when required, and the suppliers and purchasers work together to eliminate waste reducing the cost of production (Heizer & Render, 2001 [5]). In a web-based simulation for supply chain management employing electronic data interchange similar to POS data Machuca and Barajas (2004) [6] found significant reductions in the bullwhip effect, and supply chain inventory costs. Vendor-Managed-Inventory (VMI) is another excellent method for reducing the bullwhip effect, and it has been employed by many international companies, such as Procter & Gamble and Wal-Mart, but the problem associated with this method is the sharing of information between retailer and factory (Lee et al. 1997a,b) [4].

Warburton, Hodgson and Kim (2004) [7] developed equations to compute the order and demand to nullify the bullwhip effect using a generalized order-up-to (OUT) policy. Control theory is another popular approach to reduce the bullwhip effect. Lin, Wong, Jang, Shieh, and Chu (2004) [8] applied z-transforms to reduce the bullwhip effect. Many other researchers used computational intelligence techniques such as fuzzy logic, artificial neural networks, and genetic algorithms to reduce the bullwhip effect (O’Donnell et al. 2006) [9] .

A correct measurement is an essential start to investigating problems caused by demand amplification and to assess which measures can be taken to reduce this amplification. Fransoo and Wouters (2000) [10] explained three issues in measuring the bullwhip effect: first, the sequence of

aggregation of demand data, second filtering out the various causes of the bullwhip effect, and last the inconsistency in demand. Operational researchers also have worked on finding ways to reduce the bullwhip effect. Simulation also has been used in supply chain management to study the bullwhip effect. The beer game is a hands-on simulation that demonstrates material and information flows in a supply chain. As mentioned previously, it was developed by System Dynamic Group of Sloan school of Management at the Massachusetts Institute of Technology. Using the beer game, Stermane (1989)[11] demonstrated that the players systematically misinterpret feedback and non linearities, and under estimate the delays between action and response, which leads to bad decisions making and causes problems in the behaviour of the supply chain (Torres &Moran 2006)[12]. Machuca and Barajas' (2004) [6] web-based simulation using an electronic data interchange resulted in significant reductions in the bullwhip effect and supply chain inventory costs.

3. DESCRIPTION OF THE BULLWHIP EFFECT

With the accelerating trend of global economic integration in order to survive in the fierce market competition the links between enterprises become increasingly close, especially between upstream and downstream enterprises. In order to respond market demand quickly, around the core business, the suppliers, the supplier's suppliers, the core business, clients and customers form the chain structure-Supply Chain. This chain includes supply, production and sales. At the same time supply chain management has come into being. *The effect of demand fluctuations is amplified widespread in the supply chain, this demand information distortion phenomenon is called the "bullwhip effect" Chen et al.(2000)[13].* The bullwhip effect is a dynamical is a dynamical phenomenon in supply chains. It refers to the tendency of variability of order rates to increase as they pass through the echelons of a supply chain towards producers and raw material suppliers. Bullwhip creates unstable production schedules. These unstable production schedules are the cause of a range of unnecessary costs in supply chains. Thus the bullwhip effect can be quite exasperating for companies; they invest in extra capacity, extra inventory, work over-time one week and stand idle the next, whilst at the retail store the shelves of popular products are empty, and the shelves with products that aren't selling are full. The figure 1 shows the Bullwhip effect. (Dejonckheere et al., 2003)[14]

4. CAUSES OF THE BULLWHIP EFFECT

Originally, the bullwhip effect was ascribed mainly to the irrational behaviour of individuals Forrester and Sterman both assigned behavioural causes to the bullwhip effect. Later, since Lee et al. much research focussed on the operational causes of phenomena.

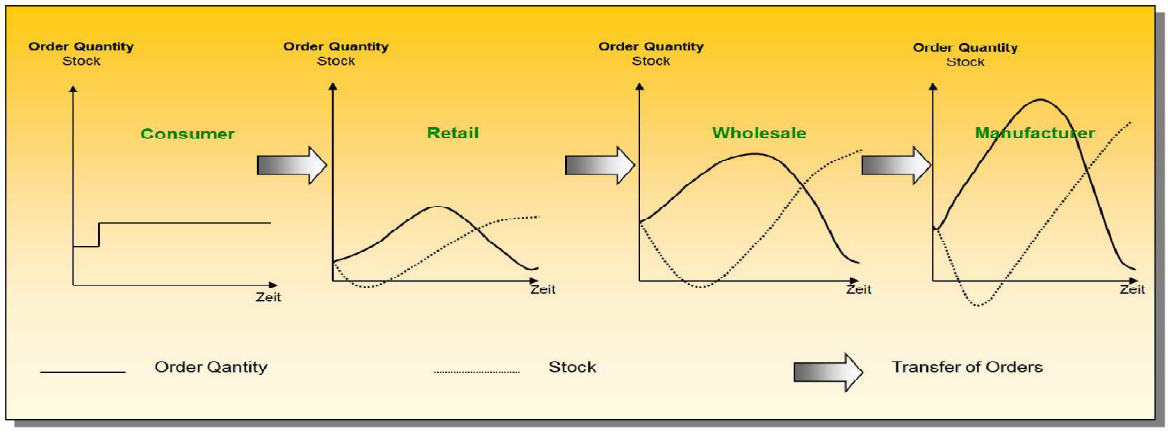

Fig. 1 Bullwhip effect

4.1 Behavioural causes

Forrester suggested that the decision logic of the individuals that are responsible for in demand management creates a tendency to over-respond to increases or decreases in demand from customers in terms of order placed on the immediate upstream neighbours. If customers demand increases. Demand to the upstream neighbour is further increased to meet the increase of customer demand. Demand to the upstream neighbour is further increased to replenish inventory, which was depleted by the initial increase of customer demand. The same exaggerated effects can occur if customer demand drops.

4.2 Operational Causes

Lee et al. showed that the bullwhip effect is not solely a result of irrational decision making, but a consequence of the player's rational behaviour within the supply chain's infrastructure. Lee et al. identified four high level causes of the bullwhip effect:

1. Demand forecast updating
2. Order batching
3. Price fluctuation
4. Rationing and shortage gaming

4.2.1 Demand forecast updating

Every company in a supply chain usually does forecasting for its production scheduling, capacity planning, inventory control, and material requirement planning. Forecasting is often based on order history from the company's immediate customers. The outcomes of the beer game are the consequence of many behavioural factors. An important factor is each player's thought process in projecting the demand pattern based on what he or she observes. When a downstream operation

places an order, the upstream manager processes that piece of information as a signal about future product demand. Based on this signal, the upstream manager readjust his or her demand forecasts and in turn, the order is placed with the suppliers of the upstream operation. We contend that demand signal processing is a major contributor to the bullwhip effect.

4.2.2 Order Batching

In a supply chain, each company places order with an upstream organisation using some inventory monitoring or control. Demands come in, depleting inventory, but company may not immediately place and order with its supplier. It often batches or accumulates demand before issuing an order.

Consider a company that order once in a month from its suppliers. The supplier faces a highly erratic stream of orders. The supplier faces a highly erratic stream of orders. There is a spike in demand at one time during the month, followed by no demands for the rest of the month. Of course, this variability is higher than the demands the company itself faces. Periodic ordering amplifies variability and contributes to the bullwhip effect.

4.2.3 Price Fluctuation

When a product price is low (through direct discounts or promotional schemes), a customer buys in bigger quantities than needed. When the product's price returns to normal, the customer stop buying until it has depleted its inventory. As a result, the customer's buying pattern does not reflect its consumption pattern, and the variation of the buying quantities is much bigger than the variation of the consumption rate- bullwhip effect.

4.2.4 Rationing and Shortage Gaming

When product demand exceeds supply, a manufacturer often rations its product to customers. For example, the manufacturer then allocates its product in proportion to the amount ordered by different retailers. Retailers often anticipate on potential shortages by exaggerating their real needs when they order. If demand drops later, this will lead to small orders and cancellations. Lee et al [4] call this overreaction by customers, rationing and shortage gaming. This "gaming" results in misleading information on the product's real demand. To illustrate the effects of rationing gaming on the variance amplification, consider a supply chain consisting of a manufacturer, multiple wholesalers, and multiple retailers. If the manufacturer appears to be in short of supply, wholesalers will play the rationing game to get a large share of the supply. Assessing a possibility of the wholesaler not getting enough from the manufacturer, retailers also play the rationing game. The effect is that demand and its variance are amplified as one moves up the supply chain-bullwhip effect.

5. REMEDIES TO THE BULLWHIP EFFECT

Lee et al. described four operational causes of the bullwhip effect. This section is concerned with proposed remedies to counteract these four causes.

5.1 Collaboration

Probably the most obvious remedy to the problem is collaboration between the supply chain members. Cancella et al [15]. defines collaboration in supply chain as "transforming suboptimal solutions of individual links into comprehensive solution through sharing customer and operational information" Several authors have shown how collaboration could reduce the amplification of orders in the upstream direction (Chen et al.)[13]

5.2 Remedies to Order Batching

Small order batches and low order frequencies are expensive. One reason is that the relative cost of placing order and replenishing it becomes higher if the order size decreases and/or if the order frequency increases. A remedy is the use of Electronic Data Interchange (EDI), which is a method for transferring data between different computer systems or computer networks. EDI can reduce the cost of paper work in generating an order, which leads to more frequent ordering by customers

5.3 Remedies to Price Fluctuation

Companies sometimes buy items in advance of requirements in reaction to price fluctuations. These price fluctuations often result from promotions like price discounts, quantity discounts and coupons. Lee et al found that costs of such practice often outweigh the benefits and therefore it is better to stabilize prices. A common way to do this is with an *ever day low price policy* (EDLP). With EDLP companies offer no discounts but promises stable low price which saves customers the effort and expense connected to price fluctuation.

6. DISCUSSION

The bullwhip effect is an obstinate phenomenon that will always be present in supply chains and cannot be completely eliminated. Since Forrester's pioneering work in 1961, much research have done on bullwhip effect. Many authors across a range of academic disciplines showed the existence of the effect.

Since the papers of Lee et al., there is little discussion about the causes of bullwhip effect. Unfortunately, countering the effect is in many practical situations not that simple. Despite all research that has been done on the subjects it remains difficult to forecast the exact impact of certain changes or decisions in general. There are many factors that have impact on the bullwhip effect and these factors have often contradictory impact of certain changes or decisions in general.

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