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A Review on Reducing Bullwhip Effect in Supply Chain Management Dependent on Many Suppliers Through Forecasting

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Abstract- In this study the review on the investigation of the causes of Bullwhip effect (BWE) associated with supply chain management is presented. It refers to a trend of large and larger swing in inventory in response to changes in customer demand swings in demand due to changes in customer demand throughout the whole process from supplier to customer. Supply chain management consists from raw material suppliers to customers. There are several stages in this chain. In this paper presents a details classified study of the overall research studied on the effect of both the operational and behavioral factors on bullwhip effect, one of which is customer demand forecasting. In this study, impact of forecasting methods on the bullwhip effect and mean square error has been considered Step taken by the various industries in order to tackle the bullwhip effect is also discussed in this paper. Finally the various scopes for further researches and instructions of the present and newer companies are also provided in this paper.

Key words - supply chain management, bullwhip effect, demand fluctuations, accurate forecasting, manufacturing, and materials demand.

2. Introduction

Supply chain management (SCM) is a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses and stores so that merchandise is produced and distributed at the right quantities, to the right location and at the right time in order to minimize system wide cost while satisfying service level requirement. It can also be defined as the coordination of production, inventory, location and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served.

"Bullwhip effect" is one of the major obstacles in supply chain management. Due to in coordination the manufacturer can't forecast the actual demand of the customer. Actual demand is fluctuated among the stages. This demand fluctuation and the demand information distortion phenomenon is called "Bullwhip effect". The retailer is not interested to know the reason for the sudden demand of the products or services. They think that the demand has increased more than the previous time so the retailer demands more products to the distributor. By this way it reaches to the suppliers in an extensive demanded form which is many times than the actual demand of the customer. The demand is oscillated within the stages of the supply chain. This oscillation of demand amplifies the demand along the supply chain. There are many studies to identify the causes of the Bullwhip effect. However the most "real world" supply chains are not easy to access. The supply chain process is consists of several stages. So it is difficult to identify the actual reason for BWE.

BWE is a forecast driven problem. Bullwhip effect is a dynamic phenomenon and is the reason of the tendency of the variability of the order rates. Bullwhip creates unstable production schedules are the cause of a range of unnecessary costs in supply chains. Companies have to invest in extra capacity to meet the high variable demand. This capacity is then under-utilized when demand drops. In the previous period many studies had described different modeling and causes of Bullwhip effect. The Bullwhip effect can be described by different modeling. Analytical, agent- based and

simulation modeling have been discussed in. One the major problem in supply chain management is Bullwhip effect that associated numerous reasons for it related to information distortion, demand fluctuation, price variations and other reasons.

These reasons have been discussed in different way. The lead time variability, local optimization within functions or stages, demand forecasting error, large lead time for information shearing, lack of supply chain coordination and other causes have been interpreted by investigation. Therefore, in this paper presents a details classified study of the overall research studied on the effect of both the operational and behavioral factors on bullwhip effect. Step taken by the various industries in order to tackle the bullwhip effect is also discussed in this paper. Finally identified the various scopes of the further research for the future researchers and instructions of the present and newer companies are also provided in this paper. The bullwhip effect can be explained with a quadratic equation by the amplification of the order rate from customer to manufacturer. Customer service at its most basic level means consistently high order fill rates, high on-time delivery rates and very low rate of products returned by customers. Internal efficiency in an organization of a supply chain means that these organizations get an attractive rate of return on their investments in inventory and other assets, and also find ways to lower their operating and sales expenses.

A typical supply chain includes the following stages:

- Customer
- Retailer
- Wholesaler/distributor
- Manufacturer
- Component/raw material supplier

3. Objectives of Supply Chain

The main objective of the supply chain is to add value to a product or in other words to increase the throughput while simultaneously reducing both inventory and operating expenses. Throughput refers to the rate at which sales to the end customer occur. Supply chain management is a tool to accomplish following strategic objectives:-

- Reducing working capital
- Taking assets of the balance sheet
- Accelerating cash to cash cycles
- Increasing inventory turns

4. Bullwhip effect

Bullwhip effect is a problem which is related with the supply chain management. Supply chain management is related from the customer to raw material suppliers. The bullwhip effect is an observed phenomenon and forecast driven. The Bullwhip effect is mainly the fluctuation of the demand of product. When the information of demand order is distorted from stage to stage in the supply chain management, the demand order is fluctuated along the supply chain. Bullwhip effect is a trend of large and larger swing in inventory in response to changes in customer demand. The concept of Bullwhip effect was first appeared in Industrial Dynamics (1961) by “Jay Forrester”

5. Effect on the Supply Chain Performance

Lack of coordination in a supply chain occurs if each stage optimizes only its local objectives, without considering the impact on the complete chain. The performance of the entire supply chain is impaired if each stage of the chain tries to optimize its local objectives. Lack of coordination also results in information distortion within the supply chain. The performance measures which are directly affected by the lack of supply chain coordination are:-

- Manufacturing Cost
- Inventory Cost
- Replenishment Lead Time
- Transportation Cost

- Labor Cost for Shipping and Receiving
- Level of Product Availability
- Relationship Across the Supply Chain
- The lack of coordination reduces the profitability of a supply chain by making it more expensive to provide a given level of product availability.

6. Objectives of the Project

The objectives of the present research work are as follows:

1. Understanding the basic structure of supply chain network and the concept of BWE.
2. Determination of BWE and MSE through demand generated using different demand patterns.
3. Analysis of the results using statistical methods.
4. Optimization of parameters for minimum BWE and MSE.

7. Literature Review

S.M. Disney and D.R. Towill (2001) presented a discrete control theory model of a generic model of a replenishment rule. They analysed that the way to minimise the bullwhip problem with given policy is to increase the average age of forecasts and reduce the rate at which inventory correction are accounted for in the production/distribution-ordering algorithm.

J. Dejonckheere et al. (2004) examined the beneficial impact of information sharing in multi-echelon supply chains. They compared a traditional supply chain and an information enriched supply chain. In the traditional supply chain, a smoothing policy can lose its dampening abilities at higher levels of the chain, whereas in the information enriched chain, smoothed order rates may be realised by all levels in the chain.

HX Sun and YT Ren (2005) made a comparison between different forecasting methods, and some practical guidelines are developed to help managers to select a forecasting method that yields the greatest desired benefit. Results shown that increase in variability will be greater for longer lead times. However, the size of the impact does depend on the forecasting methods.

Andrew Potter and Stephen M. Disney et al. (2006) considered scenarios where orders are placed only in multiples of a fixed batch size, for both deterministic and stochastic demand rates. Using simulation the impact of changing batch size on bullwhip in a production control system is shown. It has been shown that bullwhip levels from batching can be reduced if the batch size is a multiple of average demand.

Sunil Agrawal et al. (2007) analyses a two echelon (warehouse–retailer) serial supply chain. It is shown that some part of bullwhip effect will always remain even after sharing both inter as well as intra echelon information. Further, with the help of a numerical example it is shown that the lead time reduction is more beneficial in comparison to the sharing of information in terms of reduction in the bullwhip effect phenomenon.

Yanfeng Ouyang (2007) derived robust analytical conditions, based only on inventory management policies, to predict the presence of the bullwhip effect and bound its magnitude. Even with shared information the bullwhip effect will arise as long as the inventory gain is positive. To completely eliminate the bullwhip effect, suppliers have to seek policies that have negative inventory gains.

Truong Ton Hien Duc et al. (2008) quantified the impact of the bullwhip effect for a simple two-stage supply chain with one supplier and one retailer. The bullwhip effect does not always exist, but its existence depends on the values of autoregressive and moving average coefficients of the ARMA model. In fact, the bullwhip effect occurs only when the autoregressive coefficient of the demand process is larger than the moving average parameter. The bullwhip effect does not always increase when the lead time L increases.

David Wright and XinYuan (2008) provided a simulation of the effect of improved forecasting methods, and finds that Holt's and Brown's methods substantially mitigate the bullwhip effect across a range of performance metrics. It is shown that a relatively slow adjustment of stock levels, combined with a slightly more rapid adjustment of supply line levels provides the most stability when combined with either Holt's or Brown's forecasting method.

Marlene Silva Marchena (2010) showed that for certain types of demand processes, the use of the optimal forecasting procedure that minimizes the mean squared forecasting error leads to significant reduction in the safety stock level. This

highlights the potential economic benefits resulting from the use of this time series analysis.
Ling-Tzu Tseng et al. (2011) proposed a prediction system based on an evolutionary least-mean-square algorithm to estimate the downstream demand, which consequently enables the batch ordering of manufacturer to close the estimated inventory level to cope with the bullwhip effect by taking into account the holding and backorder costs.
Sunong Wua et al. (2011) applied ABMS (Agent-based model and simulation), as one of the scientific and dynamic research methods for complex system, to establish a supply chain model and determine its abundant bullwhip effect phenomenon under swarm platform. It proves the ABMS is the effective way to study the bullwhip effect in complex supply chain.
Ahmed Shaban et al. (2012) investigated the impact of various classical ordering policies on ordering and inventories in a multi-echelon supply chain through a simulation study. In addition a proposed ordering policy that relies on information sharing in a decentralized way is proposed to mitigate the bullwhip effect.
Dean C. Chatfield and Alan M. Pritchard Prabhu (2013) build a hybrid agent/discrete-event simulation model of a supply chain and execute it under various conditions of demand variance, lead-time variance, information sharing, and return allowance. They find that permitting returns significantly increases the bullwhip effect.
Borut Buchmeistera et al. (2014) simulated a simple three-stage supply chain using seasonal (SM) and de- seasonal (DSM) time series of the market demand data in order to identify, illustrate and discuss the impacts of different level constraints on the BE. The results are shown that at higher OEE level manufacturers have less variability in production processes; the BE is stronger in DSM than in SM.
Marly Mizue Kaibara de Almeida et al. (2014) provided results of trust and collaboration that lead to the mitigation of the bullwhip effect in supply chain management through a systematic literature review. The analysis found that few studies focused on addressing behavioural aspects to reduce the bullwhip effect. Most of them focused on operational and quantitative aspects.
Xiangyu Li (2015) put forward some weakening measures aimed at reasons of Bullwhip Effect including strengthening information sharing, adjusting structure of supply chain, preventing shortage game and strengthening inventory control.
Ahmad Sadeghi (2016) done a comparison of the bullwhip effect measure when two main forecasting methods i.e. exponential smoothing and moving average are used and empirical results are provided. At last, a cost analysis is conducted based on shortage and holding cost under different bullwhip effect measures.
Matloub Hussain et al. (2017) investigated the impact of capacity constraints and safety stock on the backlog bullwhip effect in a model of a two-tier supply chain. This research gives supply chain operations managers and designers a practical way to develop a trade-off between capacity and safety stock at different echelons and to take better decisions about their capacity and safety stocks.
B. Sravani and Dr. G. Padmanabhan (2018) investigated the selection of appropriate forecasting parameters in reducing bullwhip effect. The results revealed that increase of smoothing parameter levels had significant impact on bullwhip effect.
Junhai Ma and Xiaogang Ma (2018) established the supply chain model with two retailers which followed the different first-order autoregressive models and employed the order- up-to inventory policy in order to consider the market competition. It is interesting to note that market competition and the consistency of demand volatility between two retailers are also two important factors leading to the bullwhip effect apart from autoregressive coefficient, lead time and the span of forecast.

8. Bullwhip Effect Analysis

Bullwhip effect is a wasteful phenomenon that occurs due to lack of information across the supply chain. This phenomenon is one of the current challenges that a supply chain faces. This makes it essential to understand the performance of supply chain on the basis of bullwhip effect and mean square error (MSE) with the variation of process parameters. In this study bullwhip effect and mean square error are considered as measures of supply chain performance. To achieve this, the present chapter describes process parameters used for analyzing the two staged supply chain and also presents detailed methodology related to design of experiment technique based on ANOVA method.

9. Selection of accurate forecasting method

Charts only give the interaction of all forecasting with actual demand and also give accuracy and stability measure approximately. However for choosing best forecasting method for the Product related to accuracy of forecasting as discussed it is required to consider for all the forecasting methods.

10. Demand Forecasting in a Supply Chain

Forecasting of future demand is essential for taking decisions related to supply chain. Demand forecasting is the activity of estimating the quantity of a product or service that consumers will purchase in future. It involves techniques including both informal and quantitative methods. Informal methods include educated guess, prediction, intuition etc whereas quantitative methods are based on the use of past sales data or current data from test markets. It may be used in making pricing decisions, in assessing future capacity requirements, or in making decisions on whether to enter a new market not.

11. Characteristics of Forecast

These are the characteristics of forecast which supply chain managers should be aware of:-

- Forecasts are always inaccurate and should thus include both the expected values of forecast and measure of forecast error.
- Long-term forecast is usually less accurate than short-term forecast as it has a larger standard deviation of error relative to that in short-term forecast.
- Aggregate forecasts are usually more accurate than disaggregate forecasts, as they tend to have smaller standard deviationn of error.
- As we move up the supply chain away from the end consumer, the companies suffer greater information distortion. But collaborative forecasting based on sales to end customer helps upstream enterprise reduce forecast error. Collaborative forecasting is the process of setting up a continual line of communication between distributors and those customers with the ability to predict the future needs of the products they buy from the distributors.

12. Components of a Forecast and Forecasting Methods

A company should identify the factors that influence the future demand and should ascertain the relationship between these factors and future demand. Some of these factors are:-

- Past demand
- Lead time of product replenishment
- Planned advertising or marketing efforts
- State of the economy
- Planned price discounts
- Actions that competitors have taken

The companies should understand the factors first and then select an appropriate forecasting methodology.

13. Basic Categories of Forecasting Method

Forecasting methods can be divided into the following four main categories:-

- Qualitative or judgmental methods
- Extrapolative or time series methods
- Causal or explanatory methods
- Simulation

- Judgmental or qualitative methods rely on expert's opinion in making a prediction for the future. They are most appropriate when little historical data is available or when experts have market intelligence that may affect the forecast.
- Extrapolative or time series methods use the past history of demand in making a forecast for the future. The objective of these methods is to identify the pattern in historic data and extrapolate this pattern for the future. They

are based on the assumption that the past demand history is a good indicator of future demand.

- Causal methods of forecasting assume that the demand for an item depends on one or more independent factors (like price, advertising, competitor's price etc.). These methods seek to establish a relationship between the variable to be forecasted and independent variables. Once this relationship is established, future values can be forecasted by simply plugging in the appropriate values for the independent variables.
- Simulation forecasting method imitates the consumer choices that give rise to demand to arrive at a forecast. Using simulation, a firm can combine time-series and causal methods to answer questions like: What will be the impact of a price promotion? What will be the impact of a competitor opening a store nearby?

The observed demand always consists of two components that is a systematic component and random component. It is represented as:

Observed demand (O) = Systematic component(S) + Random component(R)
Systematic component measures the expected value of demand and consists of:-

- Base or current deseasonalized demand
- Trend or rate of growth or decline in demand for the next period
- Seasonality or the predictable seasonal fluctuation in demand

The random component is that part of the forecast that deviates from the systematic part.

14. Time-Series Forecasting Methods

The goal of any forecasting method is to predict the systematic component of demand and estimate the random component. In its most general form, the systematic component of demand contains a level, a trend, and a seasonal factor. The equation for calculating the systematic component may take form as shown below:-
Multiplicative: Systematic component = level × trend × seasonal factor Additive: Systematic component = level + trend + seasonal factor Mixed: Systematic component = (level + trend) × seasonal factor

15. Lack of supply chain coordination

A lack of coordination occurs either because different stages of the supply chain have objectives that conflict or because information moving between stages is delayed and distorted. Different stages of the supply chain may have conflicting objectives if each stage has a different owner. As a result each stage tries to maximize its own profits, resulting in action that diminish total supply chain profits and [10]. There is missing the coordination among these stages. For that reason the owner of a stage is not interested to know another's stage owner. There creates a lack of information shearing that is the reason of the fluctuation of demand. Finally creates Bullwhip effect.

16. Local optimization within functions or stages of a supply chain

Incentives that focus only on the local impact of an action result in decisions that do not maximize total supply chain profits [4]. One stage namely transportation manager wishes to lower transportation system that ultimately requires more time for transportation that increases the profits of the transportation manager but not the total supply chain management. This creates the variability of the available product and cause Bullwhip effect

17. Scope for the further research

Since BWE has a great influence on the supply chain system, further researches are required to eradicate BWE. There are some issues for further researches:

- It may be investigated the ways that minimizes the complexity of the supply chain.
- Finding out the ways that improve the collaboration among the stages of the supply chain.
- It may be surveyed that how many manufacturers are concern about all the causes of BWE.
- It may be researched that what will happen if one or more intermediate stages are eliminated of the supply chain.

- Investigation the gaps of the previous researches.

From the above discussion, many causes of BWE and the scope of further research were pointed out. Now this paper is providing some instructions for the present business firms and companies. First, the each stage of supply chain will be aware of the information sharing and there should have technology based way of information shearing. Second, avoid the as usual demand forecasting method and select a way that can investigate the actual customer demand. Third, the coordination must be improved among the different stages of the supply chain system to avoid disruption of information shearing. Forth, there will have a restriction against local optimization within functions or stages.

18. Conclusion:

The supply chain is a complex chain system that starts from the raw material suppliers to customers. Any type of disruption causes the BWE makes the supply chain complex. The all causes of BWE have been categorized into some categories

- causes due to supply chain processes and structure
- Causes due to material and information lead time
- Causes due to supply variability
- Causes due to other causes.

Although the modelling and causes of Bullwhip effect have been discussed extensively, there are also some limitations in the total system. Vast awareness and concentration is needed to overcome this problem. But for the most company in supply chain there are some limitations for this reason it becomes difficult to overcome this problem. From the literature review supply chain modelling and causes like long lead time, order batching, rational and shortage gaming etc. are discussed in this paper. Strong management policy and more concentration should take extensively to minimize the BWE. Often it becomes difficult to investigate the actual causes of Bullwhip effect. This review paper will help to find out the causes of BWE and provides the appropriate actions to tackle the BWE. Finally, this paper represents the scope of further research in the area of BWE. Additionally, this paper provides a brief instruction against BWE to the manufacturer. Different forecasting methods have been compared from bullwhip effect and mean square error points of view by using simulation program for determining the optimal factor.

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