Supply Chain Management: Reducing the Bullwhip Effect in SME's

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Abstract

Effective supply chain management is critical for mitigating the Bullwhip Effect (BWE) in SME's. Thus, this study examines how order batching, lead time, rationing, demand forecasting errors, information sharing and sale promotions affect the Bullwhip effect. Primary data was collected through questionnaires from 150 respondents belonging to business organizations operating in Karachi. The study finds that demand forecasting, order batching, rationing, lead-time, sales promotions and information sharing are major factors affecting the bullwhip effect. In view of these findings, organizations should seek to manage the bullwhip effect through sharing real time information and maintaining a centralized supply chain network.

Keywords: *Bull Whip Effect, Supply Chain Management.*

Introduction

Supply chain management includes four main flows, i.e. information, material, payment and ownership. In order to have an efficient supply chain system,adequate planning, managing and controlling are necessary for creating value for consumers (Christopher, 1998; Lambert, Cooper, & Pagh, 1998;). This requires close coordination between organizations within the value chain. The members within the supply chain are required to have an appropriate understanding of the network. In addition, all members must strive for creating value for customers. A problem created by one member of the supply chain will affect the efficiency of the whole supply chain. An important aspect of supply chain is bullwhip effect (BWE) which refers to unpredictable surge of demand. The bullwhip effect adversely affects the efficiency of supply chain. Forrester (1961) initially observed this phenomena and he named it as a "demand amplification".The aim of this study is to discuss the potential causes of BWE in SMEs and to find its proper solution.

Bullwhip Effect (BWE)

A well-known example of supply chain hurdles is BWE, a term coined by the logistics executives of Procter & Gamble(Lee, 1997). The concept of BWE is that a small order fluctuation from customers will amplify the orders of supply chain members including retailers, wholesalers, manufacturers and suppliers. BWE is also present even when the demand of a product is relatively constant.

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However, when these orders are placed with other chain members they would add-up to more than actual demand. This fluctuation in demand at each step of the supply chain also falls in the category of BWE that could result in declined profitability and poor customer service (Lee, 1997).

Other factors that contribute towards the BWE are order batching; demand forecast updating, rationing and price fluctuations(Lee, 1997). While ordering goods, customers keep provisions of lead-time and safety stocks that also contributes towards BWE. Price discounts and promotions also affects buying pattern that creates higher variability of demand. Due to the higher demand, manufacturers and suppliers have to revise their production plans. This not only increases the inventory holding cost and lead-time but also contributes towards BMW. Thus, BWE is known as the "cause of demand amplification" and "order batching".

Background

BWE is an old phenomenon. During the World War 2, bullwhip effect created a huge problem in the production of fighter aircrafts. There are many studies on bullwhip and boom-and-bust scenario associated with trade cycles. The bullwhip phenomenon under the name demand amplification was first documented in the USA by Forrester(1961) and then in UK by Burbidge (1984). Some of the possible solutions for decreasing the bullwhip effect was proposed by Forrester (1961) based on a DYNAMO simulation model by Burbidge (1984) based on his shop floor observation supplemented by industrial engineering analysis (McCullen & Towill, 2002). The redesigned models have been successfully implemented in supply chains to reduce the adverse consequences of BWE (McCullen & Towill, 2002).

Literature Review

This section discusses operation and behavior, causes of bullwhip and the importance of reducing bullwhip from a supply chain perspective in SME's as well as large businesses. It is one major challenge that affects the supply chain where further research is required.

Different definitions of supply chain management are available in the literature (Forrester, 1961; Burbidge, 1984; Lee, 1997). However, most authors have defined it as a network of different organizations linked together (upstream and downstream) through information flows, finances flows, and product flows to develop a product or service, which will eventually cater to customers', needs (Burbidge, 1984, Lee, 1997). A supply chain is all about catering to customer needs efficiently and effectively. Its main purpose is developing and implementing quality control, productivity, upstream and downstream activities and enhancing the firms overall performance.

Lack of coordination between the members of the supply chain may create problems such as transportation costs, material handling costs, labor-costs, lead-time, and other costs associated with shipment, delivery and inventory holding. In view of the uncertainty and variability of demand, each supply chain member carries excess inventory that increases the holding cost (Paik & Bagchi, 2007). Procter and Gamble in the 20th century

coined the termed Bullwhip. Forrester (1961) has pointed out that the amplification in the demand is due to system dynamics and supply chain delay scan be reduced by improving system dynamics. Whereas Towill (1997) also observed that improved system-dynamics will reduce cycle time, delays and BWE. They also recommended that value chain partners should share information with each other in order to improve BWE (Lee, 1997). Some researchers also observed that incomplete shipments, late products, and services delivery could also cause BWE (Lee, 1997; Hussain & Drake, 2011). The over and under production problems leads to poor customer satisfaction due to which companies lose their loyal customers (Hussain & Drake, 2011). A few techniques developed by researchers are available that can minimize the BWE. These include genetic algorithms (O'Donnell, 2006), fuzzy inventory controllers (Xion & Helo, 2006) and distributed intelligence (Fuente, 2007). These techniques may help in identifying the causes and possible remedies but could not eliminate bullwhip effects completely (Hussain & Drake, 2011).

BWE and Supply Chain Operations

Supply chain operation helps in increasing the productivity of organizations. Service sector organizations make their operations efficient which helps in reducing cycle-time, work-in-process inventory, provides better ways to material handling, develops better environment and improved customer services that are the main functions of supply. Inefficient supply chain operation leads to many problems that cause bullwhip in supply chain (Fuente, 2007).

Order Batching

Order batching is one of the main causes of the bullwhip effect. It refers to the art of placing orders at upstream levels in batches. Batching of different lot sizes directly relates to the inventory holding cost so it is important to find optimum order batching or lot sizes. For example, a wholesaler gets the demand order from retailers in smaller quantities but the wholesalers forwards the order to the manufacturer in terms of full truck or full container load in order to reduce the cost of transportation or getting discounts on large orders. The manufacturer produces the same based on wholesalers' requirement and by keeping a provision of safety stock. These issues are present in transportation and manufacturing processes because orders are in batching or lot size (Hussain & Drake, 2011). However, ordering less and more frequently can reduce the impact of bullwhip which will also help the suppliers to determine the actual demand (Ali & Kumar, 2016).

Lead Time with Demand Forecasting

It refers to the time delay or time required for fulfilling customer order. A longer lead-time will create a higher demand forecasting errors, which will also give incorrect data for successive periods. Variability in demand is due to lead-time. Thus, retailers forecast their demands by keeping provision of lead-time, despite the fact that actual demand may be more or less than the projected demand (Jaipuria & Mahapatra, 2014).

Rationing

Manufacturers usually produce their products in a limited quantity to avoid excess inventory. However, if retailers and wholesalers in view of perceived shortage may order in large quantities that may create false demand. To fulfill these orders manufacturers may increase their production capacity, which due to these unrealistic orders may eventually lead to excessive inventory stock (Mitra, & Datta, 2014).

Demand Forecast Errors

Demand forecasting is based on previous orders received from customers. However, when an order flows upstream in a supply chain, it reforms in accordance with the requirements of supply chain partners but it might not reflect the actual demand of the customers (Mitra, & Datta, 2014). Supply-chain partners at times do not share their information with the other partners, which creates fake or unrealistic demand in the supply chain. Although there are many techniques available to forecast the actual demand but they lack accuracy and thus create errors and BWE in supply chain (Wu, Chuang & Hsu, 2014).

Lack of Information Sharing

The lack of information sharing is one of the major causes of BWE; it links all the other causes of bullwhip since accurate information of customer demand would not be communicated in the supply chain (Wu, Chuang & Hsu, 2014). This causes demand forecasting errors, lead time, prices fluctuations, rationing and shortage, excess inventory stock, stock-out situation, poor customer service level (Maruyama, & Wu, 2015). This lack of trust on part of some members may increase profitability in the short run but leads to BWE in their supply chain system in the long run (Wu, Chuang & Hsu, 2014).

Sales Promotions and Price Variations

Usually companies offer sales promotion by giving price or quantity discounts to increase sales. Customers also buy in larger quantity when firms offer price or quantity discounts. This bulk buying by customers due to sales promotion will eventually result in demand fluctuations and may not reflect the actual sustainable demand (Pal, Sana & Chaudhuri, 2015). After sales promotion prices generally stabilized and customers might stop buying or may switch to other substitutes. This temporary upsurge in demand leads to forecasting errors, excess inventory, overtime expenses, poor customer service level, quality problems, higher raw material cost, shipping cost and inaccurate production schedule. Studies have found that 80% of the transactions between suppliers, manufacturers, wholesalers and retailers are based on forward buy agreements, as they want to avail the offered benefits of discounts and promotions. (Pal, Sana & Chaudhuri, 2015).

Hypotheses

Based on the above discussion the following hypotheses have been developed:

H1: The predictor variables (i.e. order batching, lead-time, rationing, demand forecasting, information sharing and sales promotion) will affect BWE.

H1A: Order batching will positively effect BWE.

H1B: Lead-time will positively effect BWE.

H1C: Rationing will positively affect BWE.

H1D: Demand forecasting will positively affect BWE.

H1E: Information sharing will positively affect BWE.

H1F: Sales promotion will positively affect BWE.

Methodology

Research Population and Sample Size

The research population for this study includes the key members of supply-chain located in Karachi. We contacted different retailers, wholesalers, distributors, manufacturers and raw material suppliers through email and face-to-face discussions to obtain appropriate and accurate data. Since Karachi is the main hub of business in Pakistan it was the selected for this research. The study had a sample size of 150 respondents.

Scale and Measures

The constructs used in this study have been adapted from earlier studies. The questionnaire in this study was based on the five point Likert scale. It had seven constructs and three to five items in each construct as detailed in Table 1. The adopted constructs reliability ranged from 0.76 to 0.87.

Table 1: Constructs

Construct	Items	Source	Original
Order batching	3	(Eicker & Cilliers, 2016).	.84
Lead time	3	(Abor, 2010)	--
Rationing	4	(Jarrett, 2014)	--
Demand forecasting	4	(Abor, 2010)	.83
Information sharing	4	(Kumar, 2016)	.83
Sales promotion	3	(Kumar, 2016)	--
BWE	4	(Hussain. et.al, 2011)	.87

Data Analysis Technique

Multiple regression analysis was carried out to examine the relationship between the independent variables (i.e. order batching, lead time, rationing & short gaming, demand forecast errors, sale promotion and lack of information sharing)and the dependent variable (i.e. BWE in supply chain).

Results

Descriptive Analysis

Descriptive analysis was performed to understand the basic features of the data set. The parameters including the mean, standard deviation and reliability statistics (Cronbach's Alpha) were computed. The results are presented in Table 2, and the reliability of constructs reported in earlier studies are presented in Table 1.

Table 2: Descriptive Statistics

Construct	Mean	Standard Deviation	Cronbach's Alpha
Order batching	2.59	1.21	0.77
Lead time	2.53	1.08	0.86
Rationing	2.57	1.10	0.82
Demand forecasting	2.51	1.01	0.76
Information sharing	2.23	1.05	0.84
Sales promotion	2.52	1.14	0.81
BWE	2.58	1.01	0.85

Table 2 shows that respondents opinion on information sharing (Mean=2.23, SD=.1.05) was the lowest followed by demand forecasting (Mean=2.51, SD=1.01), sales promotion (Mean=2.52, SD=1.14), lead time (Mean=2.53, SD=1.08), rationing and sharing (Mean=2.57, SD=.1.10), BWE (Mean=2.58, SD=1.01) and order batching (Mean=2.59, SD=1.21).

Table 2 also shows that the highest reliability is of lead-time (α=0.86, Mean=2.53, SD=1.08) followed by BWE (α=0.85, Mean=2.58, SD=1.01), information sharing (α=0.84, Mean=2.23, SD=1.05), rationing and short gaming (α=0.82, Mean=2.57, SD=1.10), sales promotion (α=0.81, Mean= 2.52, SD=1.14),and demand forecasting (α=0.76, Mean=2.51, SD=1.01). Cronbach's alpha values for all the construct is greater than 0.70, indicating acceptable internal consistency for the adopted constructs (Hair Jr, & Lukas, 2014)

Correlation Analysis

Correlation analysis was carried out to measure distinctiveness and uniqueness of the adopted construct and to check the issue of multicollinearity. Summarized results are presented in Table 3.

Table 3: Bivariate Correlations

Construct	1	2	3	4	5	6
Ord. batching	1					
Lead time	.48**	1				
Rationing	.35**	.29**	1			
D. forecasting	.37**	.26**	.47**	1		
Inf. sharing	.48**	.43**	.35**	.26**	1	
S. promotion	.28**	.28**	.44	.45**	.24**	1

*Significant at 95% confidence level, ** significant at 99% confidence level

Table 3 shows that the correlation was highest for the pair BWE and order batching. On the other hand, the lowest correlation was for the pair sales promotion and BWE. Since all the correlations are lower than 0.90 it confirms that the constructs have no issue of multi-collinearity (Bryman, 2015).

Hypothesis 1

The hypothesis that all six predictor variables (i.e. order batching, lead-time, rationing, demand forecasting, information sharing and sales promotion) will aggregately affect BWE was tested through multiple regression. The results are presented in Table 4.

Table 4: RegressionAnalysis

Construct	Beta	SE	St.Beta
Order batching	-0.470	0.068	-0.560
Lead time	0.190	0.072	0.203
Rationing	0.052	0.072	-0.257
Demand forecasting	0.282	0.079	0.283
Information sharing	0.373	0.073	0.835
Sales promotion	0.120	0.069	0.134
Constant	0.542	0.227	-

(R^2= 0.428, F (6,150) =7.164, p< 0.05)

The results of the regression analysis for the overall model indicates that the predictors variables (i.e. order batching, lead-time, rationing, demand forecasting, information sharing and sales promotion) explain 42.82% of the variance in the dependent variable (R2= 0.428,, F (6,150) =7.164, p<.05). Although the overall model fitted very well, but the effect of order-batching (β=-.5650,p=.001<.05) and rationing (β=-.25750,p=.001<.05)was significantly negative.

Hypothesis 1A

The hypothesis that order batching will affect BWE was tested. The results presented in Table 4 shows that order batching has a statistically significant negative impact on BWE (β=-.560,p<.05).

Hypothesis 1B

The hypothesis that lead-time will affect BWE was tested. The results presented in Table 4 shows that lead time has a statistically significant positive impact on BWE (β=0.203,p<.05).

Hypothesis 1C

The hypothesis that rationing will affect BWE was tested. The results presented in Table 4 shows that rationing has a statistically significant negative impact on BWE (β=-.257, p<.05).

Hypothesis 1D

The hypothesis that demand forecasting will affect BWE was tested. The results presented in Table 4 shows that demand forecasting has a statistically significant positive impact on BWE (β=.283, p<.05).

Hypothesis 1E

The hypothesis that information sharing will affect BWE was tested. The results presented in Table 4 shows that information sharing has a statistically significant positive impact on BWE (β=.835 p<.05).

Hypothesis 1F

The hypothesis that sale promotion will affect BWE was tested. The results presented in Table 4shows that sales promotion has a statistically significant positive impact on BWE (β=.134, p<.05).

Discussion

Hypothesis 1

The hypothesis that the predictor variables (i.e. order batching, lead-time, rationing, demand forecasting, information sharing and sales promotion) will aggregately affect BWE

was accepted. Supply chain operation helps in increasing the productivity of organizations. Service organizations make their operations efficient by reducing cycle-time, work-in-process inventory, material handling, better environment and improved customer services that are the main functions of supply chain. Inefficient supply chain operations leads to many problems that cause bullwhip effect (Fuente, 2007).

Hypothesis 1A

The hypothesis that order batching will positively affect BWE was not supported by the results (Refer to Table 4).Order batching is one of the main causes of the bullwhip effect. It refers to the art of placing orders at upstream levels in batches. Batching of different lot sizes directly relates to the inventory holding cost so it is important to find optimum order batching or lot sizes.

Hypothesis 1B

The hypothesis that lead-time will positively affect BWE was accepted (Refer to Table 4).A longer lead-time will create higher demand forecasting errors, which will also give incorrect data for successive periods. Variability in demand is caused by lead-time. Thus, retailers forecast their demands by keeping provision of lead-time despite the fact that actual demand may be more or less than the projected demand (Jaipuria & Mahapatra, 2014).

Hypothesis 1C

The hypothesis that rationing will positively affect BWE was not supported by the results (Refer to Table 4). Manufacturers usually produce their products in a limited quantity to avoid excess inventory. However, if retailers and wholesalers in view of the perceived shortage may order large quantities that might create false demand. To fulfill these orders manufacturers may increase their production capacity, which due to these unrealistic orders may eventually lead to excessive inventory. This rationing makes it difficult to forecast or determine actual demand of the market (Mitra & Datta 2014).

Hypothesis 1D

The hypothesis that demand forecasting will positively affect BWE was accepted (Refer to Table 4). Demand forecasting is usually based on previous orders received from customers. However, when an order flows in the supply-chain, it reforms in accordance with the requirements of supply chain partners but it might not reflect the actual demand of the customers (Mitra & Datta, 2014). Supply-chain partners at times do not share their information with the other partners, which creates fake or unrealistic demand. Although, there are many techniques available to forecast the actual demand but they lack accuracy and create errors and BWE in supply chain.

Hypothesis 1E

The hypothesis that information sharing will positively affect BWE was accepted (Refer to Table 4).The lack of information sharing is one of the major causes of BWE; it links all the other causes of bullwhip together since accurate information of customer demand is not forwarded in the supply chain (Wu, Chuang

& Hsu, 2014). This causes demand forecasting errors, lead time, prices fluctuations, rationing and shortage, excess inventory, stock-out situation, extra costs and poor customer service (Maruyama, & Wu, 2015). The lack of trust on part of some members may increase profitability in the short run but leads to BWE in their supply chain system in the long-run (Wu, Chuang & Hsu, 2014).

Hypothesis 1F

The hypothesis that sales promotion will positively affect BWE was accepted(Refer to Table 4). Usually companies offer sales promotions by giving price or quantity discounts to increase sales. Customers also buy in larger quantity when firms offer price or quantity discounts. This bulk buying by the customers due to sales promotion will eventually result in demand fluctuations and may not reflect the actual sustainable demand (Pal, Sana & Chaudhuri, 2015). After sales promotion prices are generally stabilized and customers might stop buying or may switch to other substitutes. This temporary upsurge in demand leads to forecasting errors, excess inventory, overtime expenses, poor customer service, quality problems, higher raw material cost, shipping cost and inaccurate production schedule. Studies have found that 80% of the transactions between suppliers, manufacturers, wholesalers and retailers are based on forward buy agreements as they want to avail the benefits of discounts and promotions (Pal, Sana & Chaudhuri, 2015).

Conclusion

This study finds that demand forecasting, order batching, rationing, lead-time, sales promotions and information sharing are the major factors affecting the bullwhip effect. These factors lead to longer lead-time, forecasting errors, heavy inventories, excess of safety stock and financial losses. Moreover, they can directly lead to supply chain inefficiency. The study also confirms that the BWE can be managed effectively through sharing of real time information and a centralized supply chain network.

Appendix:

	1	2	3	4	5
	Highly agree	Agree	Not sure	Disagree	Highly disagree

S.no	Statement	Rating				
1	Economic order quantity must be considered while putting order.	1	2	3	4	5
2	The discount offers motivates you to order in larders quantity.	1	2	3	4	5
3	EOQ of suppliers also be considered while putting order.	1	2	3	4	5
4	Usually supplier can take longer lead time in fulfilling order.	1	2	3	4	5
5	Having excess inventory beneficial for your firm/business.	1	2	3	4	5
6	While putting order it is necessary that you consider supplier lead time.	1	2	3	4	5
7	Customer used to order in larger quantities for getting the benefit of EOQ.	1	2	3	4	5
8	We used to cancel order in large quantities because of demand hype.	1	2	3	4	5
9	We usually increase the lead time to make demand hype in market.	1	2	3	4	5
10	Rationing and short gaming of products is better for supply chain.	1	2	3	4	5
11	We must use historical data for forecasting demand.	1	2	3	4	5
12	Historical data provides accurate demand forecasting.	1	2	3	4	5
13	JIT can be the better solution for minimizing BWE in supply chain.	1	2	3	4	5
14	By the help of JIT the errors in demand forecasting can be reduce.	1	2	3	4	5
15	We must maintain an integrated database & access methods to facilitate IS.	1	2	3	4	5
16	Firm/business effectively shares operational information between departments.	1	2	3	4	5
17	Firms share operational information externally with selected supplier and customers.	1	2	3	4	5
18	We should have SC arrangement with suppliers and customers that operate under principle of shares reward and risks.	1	2	3	4	5
19	Sale promotions and discount offers can increase demand of the product.	1	2	3	4	5
20	We usually buy in same quantity when the sale promotion ends.	1	2	3	4	5
21	Sale promotion and discount offers create artificial demand hype in market.	1	2	3	4	5
22	BWE can be reduce through effetely and efficiently use of supply chain operations and behaviors.	1	2	3	4	5

S.no	Statement	Rating				
23	We usually consider that BWE isn't present in SME's	1	2	3	4	5
24	Minimizing bullwhip leads to cost saving in overall supply chain partners.	1	2	3	4	5
25	The causes and remedies of BWE are same for local Vs. multinational firms/business.	1	2	3	4	5

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