ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 5, Issue 7, July 2016

EVALUATING THE BULLWHIP EFFECT OF SUPPLY CHAIN UNDER UNCERTAINTY ENVIRONMENT BY USING SIMULATION TECHNIQUES.

K RAMESH REDD, Dr C.NADHAMUNI REDDY ,Dr B.CHANDRAMOHANA REDDY

Abstract— The present work is mainly concentrated on the study of the influence of bullwhip effect in supply chain for variability of order quantity and variability of demand at the customer. The effect is simulated for three stage and two stage supply chain models by assuming sudden rise in the demand and sudden fall within the limits of the normal distribution. Low variability of the demand will not give any significant effect on the performance of carrying cost, short cost, and inventory total cost at various stages of the supply chain. But larger variability of the demand and will significantly effect on the performance of the supply chain.

The influence of different supply chain strategies on Bullwhip effect for different ordering polices has been analyzed to have valid and accurate results and comments. The developed supply chain model comprises two aspects; (i) estimating the product demand using MMSE, (ii) development of mathematical model and to study the impact of various parameters viz. autocorrelation (ϕ), market share (α), smoothing index (β) and lead time (*l*). To study the factors are demand forecasting technique, demand distribution type, ordering cost, holding cost, backorder cost, and demand mean, demand variance, number of forecast periods, lead time, review periods and service level, Bullwhip effect is measure for different ordering policies, inventory carrying cost of the supply chain in both the models are computed through simulation using MATLAB.

K Ramesh Reddy,Assistant professor ,Department of Mechanical Engineering,Annamacharya Institute of Technology & Sciences Tirupati,Chittoor(dist) ,A.P .- 517520.

Dr.C. Dr. C. Nadhamuni Reddy,Professor & Principal,Annamacharya Institute of Technology & Sciences, Tirupati,Chittoor(dist) ,A.P .- 517520.

Dr. B. Chandra MohanA Reddy , Assistant Professor, Department of Mechanical Engineering, J.N.T.U. College of Engineering (Autonomous), Anantapuramu

Index Terms—Supply Chain, Bullwhip Effect, Market Share, Auto regression.

I. INTRODUCTION

The bullwhip effect is a well-known symptom of harmonization troubles in conventional supply chains. The bullwhip effect is the key paradigm for supply chain incompetence. There is always mismatch in the coordination between the supply chain activities.

Supply chain management (SCM) mainly deals with the management of materials and information across the supply chain, from suppliers to manufacturers to distribution (warehouses and retailers), and ultimately to the consumer. The objective of supply chain management is to provide a flow of relevant information that will enable suppliers to provide an uninterrupted and precise flow of materials to customers. In other words, the goal of any effective supply chain management system is to reduce inventory with the assumption that products are available when needed.

The term “bullwhip effect” was at first used by Procter & Gamble, when they experienced wide-ranging demand amplifications for their diaper product “Pampers”. In the supply chain, the bullwhip effect is the majority critical problem faced by the mostly business organization that compose the most terrible crash on the entire SCM throughout. The bullwhip effect may be defined as the phenomena of the growing unpredictability of product demand additional in the upstream supply chain. It takes place due to the distended demand order irregularity in the supply chain (SC) activities because this factor stimulates up its downstream activities from its upstream activities in running of the supply chain. The variation in the product demand causes the bullwhip effect. Such situations cause giant deviation in the middle of the supplier orders and the consumer sales.

2.Literature review

Literature review of various works carried out on demand forecasting improvement of bullwhip effect, multi echelon inventory systems and performance measurement in supply chain management and related topics are presented. A major objective of the literature review is to study and follow developments& approaches in the area of supply chain management.

S. Gearya [1] studied very costly in terms of capacity on costs and stock-out costs on up streams and stock holding and obsolesce costs on the downstream. Poor material flow from one stage to another stage.

David Wright [2] the order variability is called BWE. The variability is identified and inter linked with forecasting methods. The BWE is reduced by using any ane forecasting method (Holtor Brown's forecasting methods) in scm.They was analyzes BWE in the SC using simulation and also improved forecasting methods. Using single exponential smoothing & MA to forecast demand Adjustment stock levels to supply levels.

Marko Jakšič [3] focused on demand variability increase from customer to factory moves up in supply chain to used replenishment polices such(ordering cost, stock outs holding cost of inventory, target service levels) etc. Analyzed of replenishment polices effect of lower variability of order over demand .it leads decrease the probability of the BWE.

Xiaolong Zhang [4] Investigated different combinations of lead time, price demand patterns and includes auto correlation and cross correlations, price varies these various are called BWE. The author is taken by zero lead time and also replenishment polices to be considered.

Thomas Kelepouris, [5] minimized orders in chain to reduces costs and increase customers satisfaction by make decision and replenishment policy .demand information is sharing reducing order moves up and down inventory levels in a supply chain Short lead times lead efficient operation of supply chain.

Sunil Agrawal [6] The authors are proposed two echelon system in supply chain to sharing information of lead time on bullwhip effect on inventory. Reduce the lead time as sharing information, it leads reduce the bullwhip effect. Analyzed information sharing from warehouse to retailers and used inter information sharing and intra information sharing scheme, it can lead time reduction is more comparison to sharing information.

Xiaolong Zhang [7] The author is aimed to find the optimal solution to using different forecasting methods to reduce the lead time of demand autocorrelation ,this leads to reduce the effect on BWE and also measure BWE of order policy (SS).

Man Mohan S. Sodhia [8] the author is aimed to reduce the variation of the price leads to bullwhip effect from maintenance repair and overhaul (MRO) manufacturer to constant consumption by the customer studied managerial proposition to reduce the customer's order variance and manufacturer variance in the transactions prices but also fixed ordering cost for customers' .increase of market levels.

Li Zhou [9] It many demand variable amplification of orders are make decisions by human and algorithmic of 3 straggles appropriate pass-order along demand smoothing and scheduling depending.

Qinyun Lia [10] Real life problems using numerical simulation and real life demand pattern is using damped tread forecasting qualitatively different bullwhip effect behavior and more traditional forecasting polices.

3. Supply Chain Model

The standard periodic review based stock OUT replenishment policy is used. External demand for a single item occurs at the retailer, where the fundamental demand process faced by the retailer is an AR (1) process. The retailer's demand from the customer is a demand pattern.

Notations

D_t = Total customer demand quantity in period t

α = market share retailer_1

$D_{r1,t}$ = customer demand in period t at retailer _1 with market share α

$D_{r2,t}$ = customer demand in period t at retailer_ 2 with market share $(1-\alpha)$

q_t = total ordered quantity at the beginning of the supplier in period t

$q_{r1,t}$ $q_{r2,t}$ =ordered quantity retailer_1 and retailer_2

$S_{r1,t}$ = order-up-to level by retailer _1during lead-time.

$S_{r2,t}$ = order-up-to level by retailer _2 during lead-time..

$\varepsilon_{r1,t}$ = demand forecast error iid (mean 0, varianceσ_1^2.) retailer_ 1.

$\varepsilon_{r2,t}$ = demand forecast error iid (mean 0, variance σ_1^2.) retailer_ 2.

t= time period.

$\phi 1$= the first-order autocorrelation coefficient retailer_1

$\phi 2$=the first-order autocorrelation coefficient retailer_2

δ_1=the constant of the autoregressive model.

δ_2=the constant of the autoregressive model

3.1 Demand Process

The two Retailers' of market share is considered as α and$1-\alpha$, respectively, to assumed that the order up to inventory policy Retailer_1 and Retailer_2 both are employ an autoregressive $AR(1)$ model:

$$D_{r1,t} = \alpha\delta_1 + \varphi_1 D_{r1,t-1} + \alpha\varepsilon_{f1,t} \quad \text{--------(1)}$$

$$D_{r2,t} = (1-\alpha)\delta_2 + \phi_2 D_{r2,t-1} + (1-\alpha)\varepsilon_{f2,t}. \quad \text{--------(2)}$$

Total demand $D_t = D_{r1,t} + D_{r2,t}$

3.2 Inventory Policy

In order to meet the dynamic needs of the supply chain model, the supply chain model shown in Figure 4,to employs the order-up-to inventory policy ,to assume that the two Retailer's both apply a fixed order lead time for orders. The goal of the inventory policy is to maintain inventory levels at the target inventory levels q_t. At the start of period t, the order of quantity $q_{r1,t}$ sent by Retailer_1 as follows:

$$q_{r1,t} = S_{r1,t} - S_{r1,t-1} + D_{r1,t-1} \text{----------(3)}$$

$$q_{r2,t} = S_{r2,t} - S_{r2,t-1} + D_{r2,t-1}. \quad \text{----------(4)}$$

Total ordered quantity (q_t) = $q_{r1,t} + q_{r2,t}$

Bullwhip effect = Var (qt)/ Var(Dt)

3.3 Forecasting Method

The inventory policy equation, the accuracy of the demand and forecasting of the future lead time L period is the most significant factor that affects the inventory level of the Retailer's in supply chain model. While each forecasting error is present, the impacts of various forecasting methods on the bullwhip effect are not the same. Then to introduce three forecasting methods minimizing the mean square error, moving average and exponential smoothing.

3.3.1 **The** Bullwhip Effect Measure under the MMSE Forecasting Method

Market share (α) is kept constant, autoregressive coefficient (ϕ_1) retailers _1 is varied, to find Bullwhip effect for sets of (ϕ_1, α), and reaming values of lead times of retailers _1 and retailers _2 are same (=3), autoregressive coefficient (ϕ_2) of retailers _2 (=0.6) and BWE is measured by incrementing α again. MATLAB software code written here can perform arithmetic and produce graphs efficiently. The code written to perform the computations and to produce graphs is depicted under

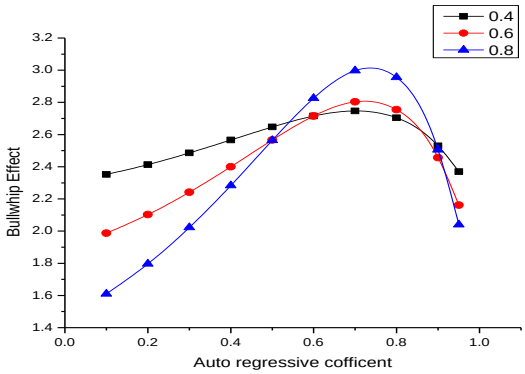

Fig 1: Influence of (ϕ & α) on Bullwhip Effect

when lead times are same for retailer_1 & retailer_2, ϕ_2 value is 0.6 constant indicates that the bullwhip effect increases slowly with the increase of ϕ_1, and the bullwhip effect begins to decrease rapidly when it reaches the maximum value. The bullwhip effect is low only for lower value of ϕ_1 and for higher values α. The bullwhip effect becomes larger with α becoming larger, and when ϕ_1 is larger than another certain value, the bullwhip effect becomes smaller with α becoming larger.

3.3.2 The Measure of the Bullwhip Effect under the MA Forecasting Method.

Market share of retailers _1 is kept constant, data span points (k) retailer _1 valueis varied, to measure the Bullwhip effect for sets of (k ,Ltr_1), and reaming values of lead times of retailer _2 are same (=3), autoregressive coefficient (ϕ_2) retailers _2 (=0.6) and BWE is measured by changing α again, since MATLAB software is written for the purpose and presented herewith.

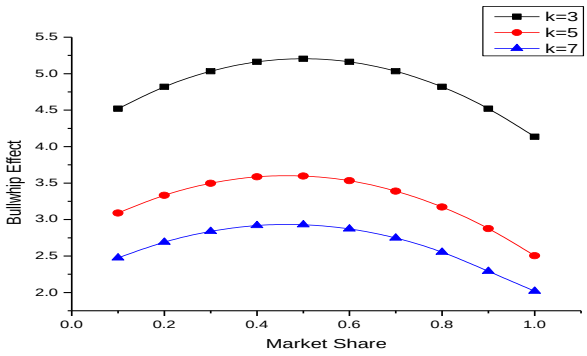

fig 2: impact of (number of periods (k) &α) on bullwhip effect

Fig shows that the trend of the bullwhip effect is increased first to the maximum and declined gradually with the increase of α. The larger the k is, the smaller the BWE.

3.3.3 *The* ***Measure of the Bullwhip Effect under the ES Forecasting Method.***

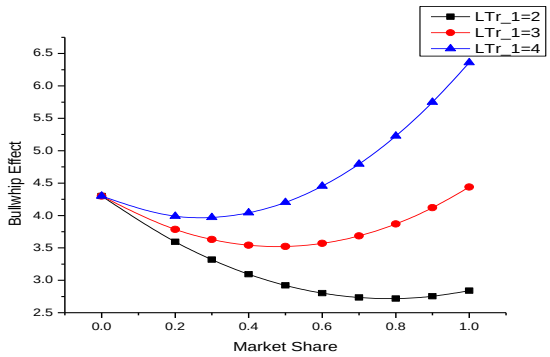

fig 3: impact of (lead time &α) on bullwhip effect

Reveals the impact of α on bullwhip effect for different LTr_1under the ES. When LTr_1takes the values of 0.4 and 0.6, the bullwhip effect decreases slowly first, after that it increases gradually. And the minimum value of the bullwhip effect occurs as the value of α is 0.5 approximately. This phenomenon indicates that the intense competition between two retailers can increase the bullwhip effect. However, when the value of LTr_1is 0.8, the bullwhip effect keeps increasing rapidly. This result is analogous with the situation.

4. The Comparison of the Forecasting Methods.

Case 1

According to the analyses above, to select appropriate parameters to compare the bullwhip effect under three different forecasting methods. To set LTr_1= LTr_2 = 3 and $\phi_1 = \phi_2 = 0.6$. Then choose appropriate k, β_1, and β_2. The MMSE method minimizes the variance of the forecasting error among all the linear forecasting methods. It obviously leads to the lowest average cost among the three forecasting approaches According to Figure 5 to take number of periods (k) = 3 and correspondingly $\beta_1 = \beta_2 = 0.5$. To measure the BWE of MMSE is the lowest of all. BWE MMSE and BWE ES decrease firstly to the minimum value and then increase with the increase of ϕ. However, BWE MA has opposite trend. When β_1 is smaller than a certain value, BWE MA is lower than BWE ES; when β_1 is larger than the certain value and smaller than another certain value, BWE MA is higher than BWE ES; and when φ is larger than another certain value, BWE MA is lower than BWEES again. It means that the MMSE forecasting method is the best to forecast lead-time demand in this situation.

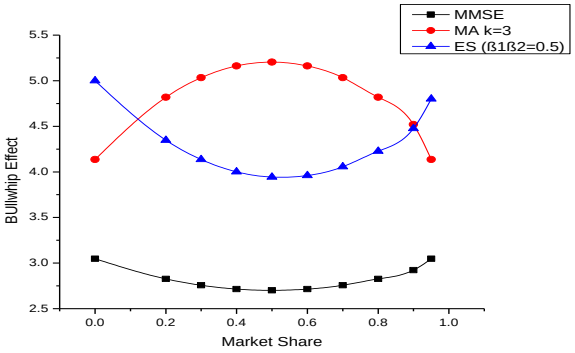

Fig 4. Forecasting methods comparison where k=3

Case 2:

Fig 5 . It means that when α is larger than certain value and smaller than another certain

value, the ES forecasting method is the best. In the other situation, the MA is the most attractive one. To concluded that better adopt ES forecasting method with the intense competition between two retailers.

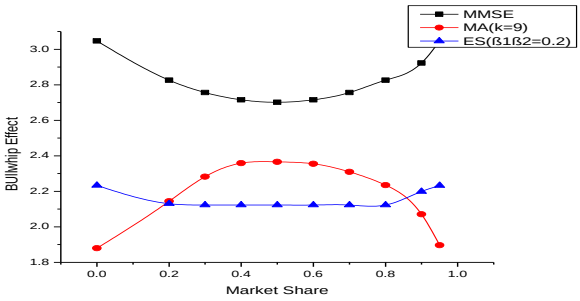

Fig 5: forecasting methods comparison where k=9

fig 6 to observed that , $\beta_1 = \beta_2 = 0.1$. In this circumstance, BWE MMSE is the highest all the time regardless different α. BWE ES is a fixed value with the increase of α. BWE MA is the lowest of all. This phenomenon reveals that the MA method is the best forecasting method whatever α is as long as number of periods k is larger.

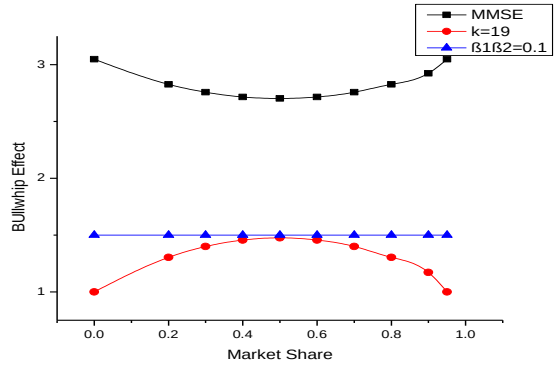

Fig 6: forecasting methods comparison k=20

5. Conclusions

Effect of the autoregressive constant of the demand method on the inventory prices consistent with the analyses higher than, to pick applicable parameters to match the bullwhip impact below 3 totally different statement ways..Then select applicable k, $\beta 1$, and $\beta 2$. The MMSE methodology minimizes the variance of the statement error among all the linear statement ways. It clearly results in very cheap monetary value among the 3 statement approaches. The trends of the 3 bullwhip effects are an equivalent. $\beta 1 = \beta 2 =$ zero.5. to known BWE MMSE is that the lowest of all. BWE MMSE and BWE Es decrease first of all to the minimum price then increase with the rise of ϕ. It implies that the MMSE statement methodology is that the best to forecast lead-time demand during this state of affairs. It implies that once α is larger than price and smaller than another certain price, the Es statement methodology is that the best. Within the alternative state of affairs, the MA is that the most tasty one. To ended that higher adopt Es statement methodology with the extreme competition between 2 retailers. $\beta 1 = \beta 2 =$ zero.1. during this circumstance, BWE MMSE is that the highest all the time regardless totally different α. BWE Es could be a fastened price with the rise of α. BWE MA is that the lowest of all.

REFERENCES

[1]. Hong LIU, Ping WANG "RESEARCH PAPER Bullwhip Effect Analysis in Supply Chain for Demand Forecasting Technology" Systems Engineering - Theory & PracticeVolume 27, Issue 7, July 2007, Pages 26–33.

[2]. Elena Ciancimino, Salvatore Cannellab, Manfredi Bruccoleria, Jose M. Framinanc, "On the Bullwhip Avoidance Phase: The Synchronized Supply Chain" European Journal of Operational Research Volume 221, Issue 1, 16 August 2012, Pages 49–63.

[3]. David Wright, Xin Yuan "Mitigating the bullwhip effect by ordering policies and forecasting methods" International Journal of Production Economics Volume 113, Issue 2, June 2008, Pages 587–597.

[4]. Marko Jakšič, Borut Rusjan "The effect of replenishment policies on the bullwhip effect: A transfer function approach" European Journal of Operational Research-Volume 184, Issue 3, 1 February 2008, Pages 946–961.

[5]. Xiaolong Zhang, , Gerard J. Burke "Analysis of compound bullwhip effect causes" European Journal of Operational Research Volume 210, Issue 3, 1 May 2011, Pages 514–526.

[6]. Thomas Kelepouris, Panayiotis Miliotis, Katerina Pramatari "The impact of replenishment parameters and information sharing on the bullwhip effect: A computational study" Computers & Operations Research Volume 35, Issue 11, November 2008, Pages 3657–3670.

[7]. Sunil Agrawal, Raghu Nandan Sengupta, Kripa Shanker "Impact of information sharing and lead time on bullwhip effect and on-hand inventory" European Journal of Operational Research-Volume 192, Issue 2, 16 January 2009, Pages 576–593.

[8]. Xiaolong Zhang "The impact of forecasting methods on the bullwhip effect" International Journal of Production Economics-Volume 88, Issue 1, 8 March 2004, Pages 15–27.

[9]. Li Zhou a, tephen Disney b, Denis R. Towillb "A pragmatic approach to the design of bullwhip controllers''International Journal of Production

Economics-Volume 128, Issue 2, December 2010, Pages 556–568.

[10]. Qinyun Lia, Stephen M. Disneya, Gerard Gaalmanb "Avoiding the bullwhip effect using Damped Trend forecasting and the Order-Up-To replenishment policy"International Journal of Production EconomicsVolume 149, March 2014, Pages 3–16.