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# A Study of Change in Bullwhip Effect: An Indian Sectoral Study

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**Abstract**

The amplification of demand as one move up in supply chain is considered as Bullwhip effect. Bullwhip effect creates disturbance in operations and supply chain management (OSCM). Overproduction or underproduction, unmanaged demand, short of cash-in-hand to carry out operations, excessive inventory carrying cost, decrease in service level and profit are the implications of bullwhip effect which result in disturbance of the entire supply chain. Bullwhip effect is experienced among all types of products, all types of sectors and all types of supply chain in varying quantum. The present study computes the bullwhip effect among 10 different Indian sectors from past 12-year data. The study analyzes the various changes that occur within these sectors in terms of bullwhip effect and seek the improvement in the bullwhip effect from first half to second half of data within that sector. Results show that the improvement in bullwhip is not significant. Surprisingly in many sectors, the correlation of bullwhip from first half to second half is negative in nature.

**Keywords:** Bullwhip Effect, Bullwhip Ratio, Indian Sector Analysis, Supply Chain Management

## Introduction

Accomplishment of supply chain management over the past three decades became essential for the growth and sustainability of an organization. Globalization, change in consumer preference, shorter life cycle of product, cut throat competition, etc. compel the organizations to streamline their production, operations and logistics management. Supply chain management comprises of many aspects like production, operations, logistics, inventory, finance, marketing and information management. Christopher (1994) defines supply chain management in terms of upstream and downstream linkage - when the flow of product and ownership is from supplier to customer such a direction is termed as downstream whereas when the flow of information and money is from customer to supplier such a direction is considered as upstream. As demand moves upstream in supply chain it amplifies and this is considered as bullwhip effect. The disruption at one end in supply chain causes poor performance and supply chain does not remain effective (Towill et al., 1992). Retailers tend to order more to wholesalers as compared to the actual demand being experienced by them as a consequence wholesalers order more to manufacturer. This amplification gets highest at supplier level as more material is supplied than what is actually required.

Many studies emphasized on the presence of bullwhip effect and also provide various remedial measures to deal with the same. Information sharing across supply chain (Wang et al., 2005), reduced number of echelon in supply chain, lead time reduction, supplier selection (Joseph & James, 2018), better pricing and promotion strategies, operational efficiency, flexibility (Naim et al., 2010; Thome et al., 2014), inventory management, vendor manage inventory (Disney & Towill, 2003), better forecasting, supply chain integration (Cagliano et al., 2006) are few remedial measures to mitigate bullwhip effect. Recently a study by Derbel et al (2014) has covered the various aspects related to bullwhip effect in supply chain management (Shekhawat, 2015). Variability among demand and supply is causing the bullwhip effect. Due to inherent dynamic nature of supply chain it is very difficult to have a perfect coherence between demand and supply. In a study on Intel it has been found that the both were on

the same ground only for few minutes in 10 years (Oliver & Haulihan, 1986). Forrester (1958) and Sterman (1989) studied bullwhip effect using simulations. Forester (1958) states that the variance in the demand of manufacturer is far greater than the variance of what actually consumers consume whereas Sterman (1989) uses the famous beer distribution game to show the increase in variability as one move up in supply chain. Besides the managerial decisions that cause bullwhip effect which have been explored and estimated using simulations (Nienhaus et al., 2006) there also exist the operational aspects that cause the bullwhip effect. Lee et al. (1997) reported four main operational reasons of bullwhip effect viz. rationing and shortage, price fluctuation, forecasting and order batching. Study by Lee et al. (1997) was based on structure of supply chain whereas previous studies were based on irrational behavior of decision makers. Later the reasons of bullwhip effect increased from four to many. Safety stock, advertisement effect, lead time, information delay, machine breakdown at factory, capacity level planning, number of echelon are the few reasons among many as identified by the researchers McCullen and Towill (2002).

Many of the reasons to counter bullwhip effect have been recognized and large numbers of solutions are given to mitigate this problem. Forecasting methods to accurately estimate the future demand, use of information technology to collect point of sales information, eliminate number of echelon in supply chain, applying techniques like JIT to deal with inventory, management information system, reducing lead time and well managed logistics are widely suggested and implemented by researchers over past two decades to mitigate bullwhip effect. Bullwhip effect has also been explored in various scenarios like market competition (Junhai & Xiaogang, 2017), and latest research techniques like genetic algorithm (O'donnell et al., 2006) are used to mitigate this amplification phenomenon. Plethora of research is available on bullwhip effect. Research database like Science Direct, Emerald and Proquest shows hundreds of studies about bullwhip effect, its mitigation and implementation of mitigation methods in the industry. Since it is not a new concept anymore companies are implementing strategies to deal with bullwhip effect. Present study seeks to study the change in bullwhip effect over a period of time in Indian industries.

The present research has the following objectives: First objective is to measure the bullwhip effect occurring in Indian sectors. Second objective is to see what changes in bullwhip effect are having over a period of last decade for these sectors.

## Literature Review

The dynamics of supply chain moves around the suppliers, manufacturer and customers in a big way, though there are few uncertainties on part of wholesalers and retailers. Manufacturer's uncertainties may be due to quality checks, shortages, machine breakdown, unavailability of raw material, etc. whereas those on customer end are change in taste and preference, change in technology etc. Due to the presence of these uncertainties they tend to place such an order to subsequent partner so that shortages will not take place and that results in bullwhip effect. Bullwhip effect is not only a concern for operations and supply chain managers but is also studied by economist like Blanchard (1983) who studied the empirical data of the automobile industry. He finds that inventory movement plays a crucial role in bullwhip effect; the study concludes that the variance in production is greater than the variance in sales after the seasonal variations are adjusted. Kahn (1987) found that to avoid stock out situations companies maintain high inventory hence the variance of inventory is more than that of sales.

Caplin (1985) studied the (S,s) inventory model and found that this policy add variability to the demand hence the variance of order exceeds the variance of sales. Chen et al. (2000) quantifies the bullwhip effect on ratio of variability of quantity ordered to the variability of quantity demanded. The study by Cachon et al. (2007) also quantifies the bullwhip effect on basis of variability of production to the variability of sales.

Past studies show that bullwhip effect is experienced in many sectors. Studies on Procter and Gamble in FMCG industry, HP in IT industry, Eli Lilly in pharmaceuticals, IBM and Motorola in electronics are benchmark case studies of bullwhip effect. Study of Bullwhip effect on automobile sector can also be cited in many recent studies. Seles et al. (2016) studied Brazil automobile sector and showed an existence of green bullwhip effect. Chiang

et al. (2016) recently studied US automobile industry and concluded that order upto policy always results in bullwhip effect and better forecasting may decrease the same. Greek retail industry experienced the bullwhip effect (Kelepouris et al., 2008) and effect increases due to increase in lead time. Hamister and Suresh (2008) explored retail sector for bullwhip effect on basis of pricing strategy. Chang et al. (2007) studied retail industry and point of sale information and augmented collaborative forecasting is suggested to deal with bullwhip effect. Telecom sector (Mahmoudi & Lamothe, 2006) also experienced bullwhip effect. Most of the above mentioned studies use the bullwhip ratio to calculate bullwhip effect. Isaksson and Seifert (2016) measure bullwhip effect using bullwhip ratio in US industries like FMCG, mining, etc. Hull (2005) carried out case study on oil sector and stated that implementation of strong administration can avoid reverse bullwhip effect in oil sector. Kaipia et al. (2006) explored electronic industry of Europe and found that bullwhip effect can be countered if nervousness in supply chain is managed.

None of the above studies explored bullwhip effect in Indian Context. Ravichandran (2006) studied bullwhip effect in Indian scenario on the basis of two case studies. In present study coefficient of variation is computed for the production as well as sales and coefficient of variation is used to compute the ratio that quantifies the bullwhip effect at manufacturer end. Such ratios are used in many studies to quantify the bullwhip effect. Fransoo and Wouters (2000) who studied bullwhip effect in food industry computed bullwhip ratio at product, outlet and echelon level in a supply chain.

At manufacturer end, if the coefficient of variance of production is more than that of coefficient of variance of sales then it is considered as presence of bullwhip effect otherwise not (Chen et al., 2000). The ratio is computed of both the quantities to signify that if ratio is greater than one then this implies presence of bullwhip effect otherwise not, i.e. bullwhip will be present if,

*coefficient of variance of production > coefficient of variance of sales*

or,

$$\frac{coefficient\ of\ variance\ of\ production}{coefficient\ of\ variance\ of\ sale} > 1$$

## Data and Research Methodology

Bombay Stock Exchange (BSE) sectoral indices represent and reflect the performance and behavior of that particular sector. It is a representative of the performance of companies that represent the movement in that specific sector selected on various factors like market capitalization, trading frequency, etc. These sectors are independent in nature hence it has been decided to study various sectors present in Indian Economy.

The leading 10 sectors of the Indian economy are studied in the present study. If finance sector is kept aside, these 10 sectors are the sectors that represent 80% of the total market capitalization of the remaining total market. Since these sectors play a vital role in Indian economy and hence chosen by interest to see the performance of these sectors. BSE sectoral indices are used to study as the companies present in these sectors symbolize the performance of sector. The sectors considered in present study are Automobile, Consumer Durable, Energy, FMCG, IT, Oil and Gas, Power, Real, Telecom and Utility sectors. Table 1 shows the number of companies belonging to 10 different sectors. BSE sectoral listed companies are selected from these sectors. From the selected companies last 12-year data is taken (from 2006 to 2017) using Prowess® Database. The variables chosen to compute the bullwhip ratio are cost of goods sold and cost of production. The cost of production denotes the manufacturing cost during that accounting period whereas cost of goods sold is the cost related to production of goods that are sold during that year.

**Table 1: Sector and Number of Companies Taken in Present Study**

| Name of Sector | Auto | CD | Er | FMCG | IT | OG | Po | Real | Tel | Ut |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Companies | 13 | 10 | 26 | 77 | 57 | 10 | 19 | 10 | 16 | 32 |

Auto: Automobile, CD: Consumer Durable, Er: Energy, OG: Oil & Gas, Po: Power, Tel: Telecom, Ut: Utility

The analysis on basis of bullwhip ratio is carried out in next section. Fig. 1 shows the detailed research methodology to achieve the objectives.

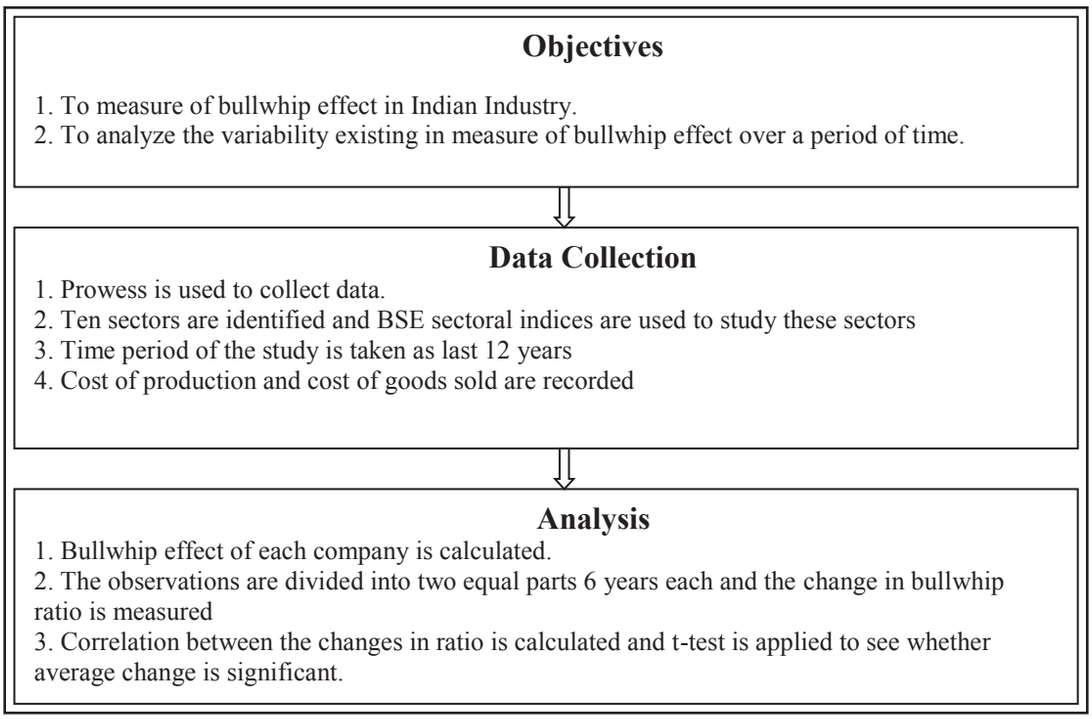



**Fig. 1: Steps in Research Methodology**

## Analysis and Results

The analysis part is broadly divided into three parts as shown in Fig. 1.

### Bullwhip Ratio

Bullwhip effect is computed for each sector. Bullwhip ratio is used as tool to compute the bullwhip effect on basis of past 12 year data. The ratio of coefficient of variation of production to that of sales is used to compute bullwhip ratio. Every sector shows the sign of bullwhip effect. Table 2 shows the percentages of companies experiencing or not experiencing the bullwhip effect.

**Table 2: Percentage of Companies Showing Bullwhip Effect in Different Sectors**

| Percentage of companies | | |
|---|---|---|
| **Name of Sector** | **BWE** | **Not having BWE** |
| Automobile | 64.29 | 35.71 |
| Consumer Durable | 70 | 30 |
| Energy | 34.62 | 65.38 |
| FMCG | 50.64 | 49.36 |
| IT | 21 | 79 |
| Oil and Gas | 50 | 50 |
| Power | 31.58 | 68.42 |
| Real | 20 | 80 |
| Telecom | 25 | 75 |
| Utility | 28.12 | 71.88 |

In automobile, consumer durable, FMCG sectors the number of companies having bullwhip effect is more than those who do not possess the same. IT sector is broadly divided into two categories hardware manufacturers (17 companies) and software service providers (40 companies). Hardware manufacturers have been experiencing bullwhip effect. Telecom, Real and Utility sectors are having least bullwhip effect whereas in oil and gas sector 50% companies are experiencing bullwhip effect. The pictorial representation of the bullwhip effect computed in different sector is shown in Fig. 2.

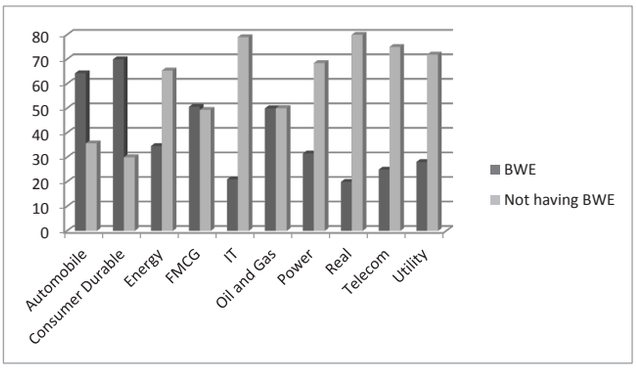



**Fig. 2: The Comparison of Percentage of Companies Showing Bullwhip Effect Against Not Showing Bullwhip Effect in Different Sectors**

## Change in Bullwhip Effect

To see the change in bullwhip effect over a period of time, the data of each sector is divided into two halves and bullwhip ratio is computed for each halves for each company. In spite of so much research being done in past two decade on bullwhip effect and presence of a fierce competitive environment where every company want to optimize their operations, the bullwhip effect has been found to increase if comparison is done form first half to second half of the time series data. This shows there is still scope left to deal with bullwhip effect effectively even in today's dynamic scenario. In automobile sector nine companies shows increase in bullwhip effect where as four shows decrease in bullwhip effect. In consumer durable sector seven companies increase in bullwhip effect and only two show decrease in bullwhip effect. Energy sector is showing decrease in bullwhip effect. In Energy sector 16 companies were able to decrease the bullwhip ratio and in comparison only five depicted increase in the same. FMCG sector showed very fluctuating results, 39 companies showed increases in the bullwhip ratio whereas 38 companies recorded decrease in the bullwhip ratio. IT sector consists of majority of solution based companies is one of the most stabilized sector. Oil and gas sector also registered decrease in its bullwhip ratio but Power sector presented the reverse trend. The results of increase, decrease and no change of all sectors are given in Table 3.

**Table 3: Number of Companies in Different Sectors that has Increase, Decrease and No Change in Bullwhip Effect**

| Number of Companies | | | |
|---|---|---|---|
| **Sectors** | **Increase in BWE** | **Decrease in BWE** | **No change in BWE** |
| Automobile | 9 | 4 | 0 |
| Consumer Durable | 7 | 2 | 1 |
| Energy | 5 | 16 | 5 |
| FMCG | 39 | 38 | 0 |
| IT | 12 | 17 | 28 |
| Oil and Gas | 2 | 7 | 1 |
| Power | 10 | 6 | 3 |
| Real | 3 | 6 | 1 |
| Telecom | 4 | 5 | 7 |
| Utility | 8 | 12 | 12 |

## T-test and Correlation Analysis

The average bullwhip ratio of each sector is computed for both the halves. To see whether the change is significant or not in bullwhip ratio, t-test is computed and correlation is also computed to see the direction corresponding to each sector. The results are shown is Table 4.

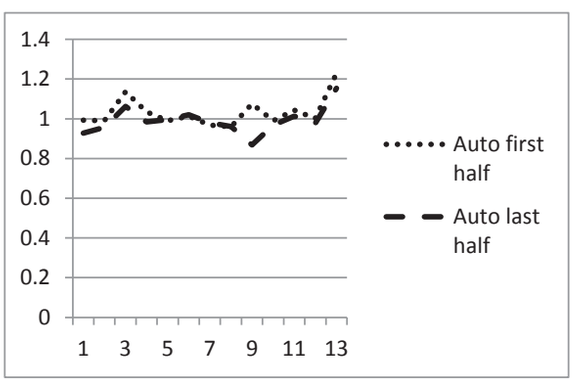
**Table 4: Table Showing T-test to Analyze the Difference in Bullwhip Effect When Data is Categorize into Two Halves**

| | **Automobile** | | **Consumer Durable** | | **Energy** | | **FMCG** | | **IT** | | **Oil & Gas** | | **Power** | | **Real** | | **Telecom** | | **Utility** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** | **f6** | **l6** |
| Mean | 1.032 | .9 | 1.32 | 1.178 | 1.02 | 0.96 | 1.03 | 1.08 | 1.02 | 1.03 | 1.143 | 0.86 | 0.969 | 1.12 | 1.00 | 1.00 | 1.147 | 1.02 | 1.06 | 1.01 |
| Var | .005 | .005 | 0.4 | 0.72 | 0.03 | 0.04 | 0.05 | 0.16 | 0.04 | 0.23 | 0.114 | .016 | .014 | 0.33 | .0003 | 5E-06 | 0.255 | .01 | .055 | 0.13 |
| Obs | 13 | 13 | 10 | 10 | 26 | 26 | 77 | 77 | 57 | 57 | 10 | 10 | 19 | 19 | 10 | 10 | 16 | 16 | 32 | 32 |
| d.f. | 12 | | 9 | | 25 | | 76 | | 56 | | 9 | | 18 | | 9 | | 15 | | 31 | |
| t Stat | 2.67 | | 0.375 | | 1.02 | | -0.79 | | -0.131 | | 2.032 | | -1.32 | | 0.33 | | 1.24 | | 0.68 | |
| t Critical two-tail | 2.178 | | 2.262 | | 2.05 | | 1.99 | | 2.003 | | 2.26 | | 2.10 | | 2.262 | | 2.13 | | 2.03 | |
| H0: | Rejected | | Accepted | | Accepted | | Accepted | | Accepted | | Accepted | | Accepted | | Accepted | | Accepted | | Accepted | |
| Pearson Corr | 0.679 | | -0.296 | | -0.352 | | -0.104 | | -0.204 | | -0.723 | | 0.631 | | -0.050 | | 0.958 | | 0.125 | |
| Sig. at 5% level | significant | | Not significant | | Not Significant | | Not significant | | Not significant | | significant | | significant | | Not significant | | significant | | Not significant | |

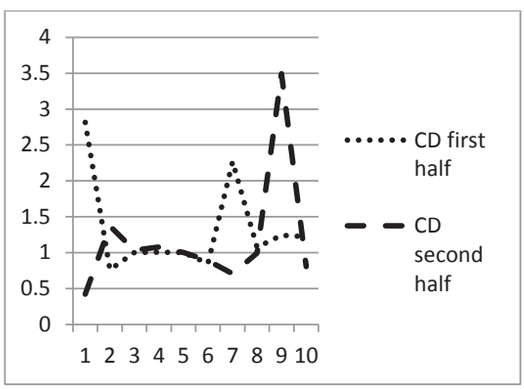
F6: first six years, L6: last six years, Var: Variance, Obs: number of observations, d.f.: Degree of Freedom, Corr: correlation, Sig.: Significance for correlation coefficient

The null hypotheses for the t-test is set as, there is not a significant difference exist between the average values of two halves of bullwhip ratio. For automobile sector the average value of last 6 years is significantly different from first 6 years and $H_0$ is not accepted and termed as rejected in this case. In other sectors, the average ratio of the bullwhip has not change significantly.

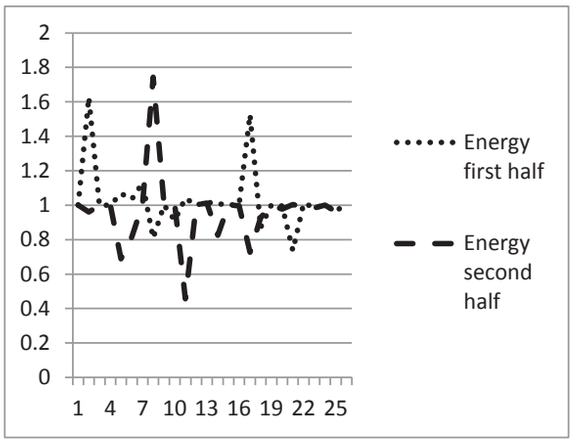
The correlation between the four sectors has been positive out of which three sectors Automobile, Telecom and Power, it is significant, where as in Utility, correlation is not significant. All other sectors are having negative correlation out of which Oil and Gas is significant (Fig. 3).



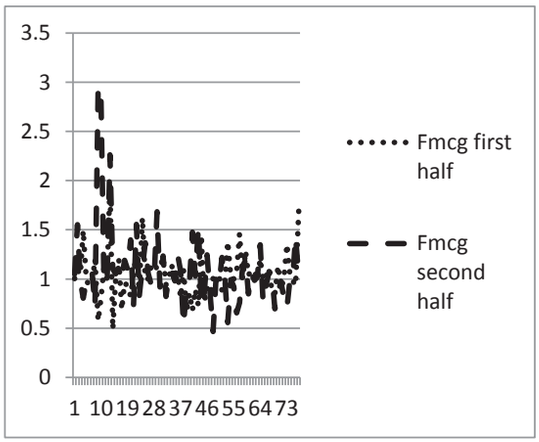

(a) Automobile Sector



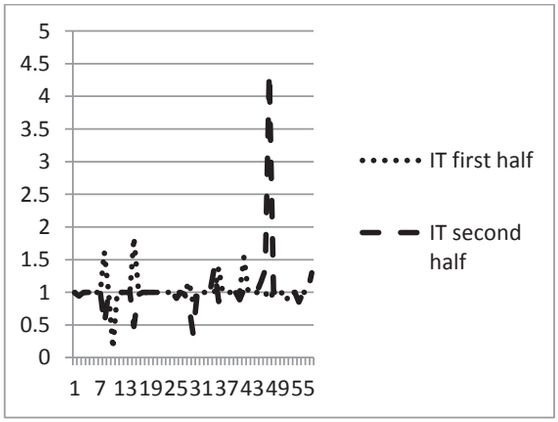

(b) Consumer Durable Sector



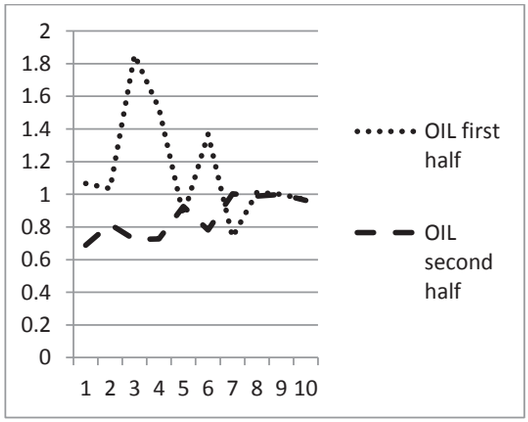

(c ) Energy Sector




(d) FMCG Sector




(e) IT Sector




(f) Oil and Gas Sector

**Fig. 3: Correlation Graph of Bullwhip Ratio When Divided into Two Halves of Different Sectors**

## Conclusion and Future Scope

Amplification of demand causing inefficiency in supply chain, hence mitigation of bullwhip effect is required for effective implementation of supply chain. This study is unique in the aspect that it is the first in Indian sectoral context considering 10 sectors at a time. These 10 sectors combine to represent the 80% of the remaining market capitalization keeping finance sector apart (which is representing 31% of market). BSE sectoral indices have been taken under study to see the performance of sectors in terms of bullwhip effect. Bullwhip ratio is computed to measure the bullwhip effect at manufacturer end and it has been found that all sectors possess bullwhip effect. Out of 10 selected sectors Automobile, Consumer Durable and FMCG sector is having high percentage of companies possessing bullwhip effect where as IT sector and Real sector is least affected. The change in bullwhip effect over a period of time has also been studied by dividing the series into two halves. The change in bullwhip ratio is found to be significant in automobile sector. The correlation is also found to be significant in 4 sectors, automobile, power and telecom is showing the positive correlation whereas Oil and gas sector is showing the negative correlation when the time series is divided into two halves. The average bullwhip ratio has not changed much but the study of correlation direction is surely a future scope of research.

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