Influence of Forecasting Factors and Methods or Bullwhip Effect and Order Rate Variance Ratio in the Two Stage Supply Chain-A Case Study

Kamasani Ramesh Reddy, Dr.C.Nadhamuni Reddy, Dr.B.Chandra Mohana Reddy

Abstract— Bullwhip effect and order variability control in the supply chain received the widespread attention of researchers and practitioners. The present study investigate the impact of forecasting factors and methods on bullwhip effect and order rate variance ratio in two stage supply chain. Moving average, simple exponential smoothing and Holt’s forecasting methods are applied and the forecast with different factors are estimated. The analysis of results shows that, the bullwhip effect increases by increasing the number of moving period for both stage of the supply chain and the bullwhip effect at manufacturing entity is relatively more than the retailer entity. The bullwhip effect is reduced when increasing the value of the smoothing constants. Moving average method yields minimal bullwhip effect than the other methods. Holt’s forecasting method with $\alpha=0.3$ and $\beta=0.3$ gives the minimal bullwhip effect than the 3 period moving average method. Order rate variance ratio also gives similar observation like bullwhip effect in the entire investigation. The present study outlines scope to reduce the bullwhip effect, but not eliminate the bullwhip effect.

Index Terms— Forecasting factor, forecast method, bullwhip effect, order variance ratio, consumer goals supply chain.

I. INTRODUCTION
Supply chain management is an integrated activity designed to attain the maximum delivery performance at competitive cost. The efficiency of the supply chain measured in terms of number of on time delivery and reduction in inventory level. However, these measures can be controlled by monitoring the variability of sales, manufacturing and supply. The effect caused due to the fluctuation of the sales manufacturing and supply is called bullwhip effect [11]. In sufficient or excessive utilization of capacity, exclusive inventory and poor delivery performance, product availability and revenue loss are considered as the major cause of bullwhip effect [29]. Identification, quantification and eliminating the bullwhip effect is the right way to manage the performance of supply chain [9]categorized the bullwhip effect in to Forrester effect (Demand and lead time signal processing), Burbidge effect (order batching effect), Houlihan effect (rationing and gaming effect) and promotion effect (price fluctuation). Among the categories the bullwhip due to demand signal processing is associated with lot of complications,[1] proposed an integrated approach of discrete wavelet transform and artificial neural network (DWT-ANN) for forecast processing. It is observed from the analysis of result; the mean square error obtained from the (DWT-ANN) approach is lower than the Autoregressive moving average approach (ARIM) [4]. Bullwhip effect and Net stock amplification estimated by (DWT-ANN) model comparatively less than ARIMA model. [4] Aimed to measure the bullwhip effect in a two stage supply chain. First order auto regressive model is applied to forecast the demand and base stock inventory policy is followed to replenish the items. Effect of auto regressive co efficient and lead time on bullwhip is studied. Analysis of result shows that the bullwhip effects increase by increasing the auto regressive co-efficient and lead time.[3] investigated the effect of auto regressive co-efficient and order lead time in the high order auto regressive demand processing. They selected two stage supply chain and followed base stock inventory policy in their proposed work. The result of numerical investigation shows that the auto regressive co-efficient and lead times have significant impact on bullwhip effect, when processing with second order auto regressive model. [11] Attempted analyse the impact of exponential smoothing forecast on the bullwhip effect in an electronic supply chain. It is observed from the result, the longer lead time and selecting poor forecasting model parameters introduce the bullwhip effect. [5] Studied the demand fluctuation caused by moving average, and exponentially weighed moving average forecasting method in a two stage supply chain single order auto regressive stochastic model is applied for demand processing. Whereas order up to inventory policy. They suggested the rules to minimize the bullwhip effect for employing these forecast methods. Discussed the impact of forecasting method on bullwhip effect for a simple replenish system. The demand is described by the first order autoregressive process and order up to the policy is followed to replenish the inventory. Analysis of the numerical investigation indicates that the forecasting method offers significant influence on the bullwhip effect. [10] Developed a simulation modeling to investigate the impact of forecast method selection on bullwhip effect and inventory performance. They selected a material requirement planning (MRP) based inventory policy to replenish the items. It is found from the results of numerical investigation the MRP based policy yields better performance in terms of reduction in bullwhip effect and improvement in inventory measure when compared to the traditional order up approach. [7] Conducted a comparative study on bullwhip effect in a single stage supply chain. They applied autocorrelated demand functional model to process the demand data. Correct, moving average and exponentially

Kamasani Ramesh Reddy, Research scholar, Department of Mechanical Engineering, JNT University Ananthapuramu, Andhra Pradesh, 515002

Dr.C.Nadhamuni Reddy, Department of Mechanical Engineering, AITS, Tirupati, Andhra Pradesh -517520

Dr.B.Chandra Mohana Reddy Department of Mechanical Engineering, JNT University Ananthapuramu, Ananthapuramu, Andhra Pradesh, 515002, india.
weighed moving average forecast method are employed to amplify the bullwhip effect. The comparative study provides the optimal solution of the bullwhip effect control policy. As a further contribution, the current deals the impact of forecasting factors and methods on bullwhip effect and order rate variance ratio in two stage supply chain.

II. PRODUCER FOR CASE DESCRIPTION

The manufacturing firm considered for this study is popular for toffee manufacturing in south India. Presently the firm is struggling with excess inventory or stock problem due to order variability. As an initial step, the demand data for the highest moving product is selected. A retailer who is dealing highest quantity order also chooses for the present investigation. Supply chain is proposed with a manufacturer and a retailer. The order flow, product flow in the proposed supply chain is shown in the figure 1. Demand at manufacturer and retailer are collected for the period of August 2014 to December 2015 and the actual order from the customer for the period of January 2015 to December 2015 also collected and presented in the Table 1. Based on the old demand data from the retailer and manufacturer (January 2014 to December 2014), the forecast for the period from January 2015 to December 2015 are estimated by using moving average, simple exponential smoothing and Holt’s forecasting method. Bullwhip effect and order rate variance ratio are evaluated from the forecast estimation for the period from January 2015 to December 2015.

![Figure 1. Two stage supply chain](image)

III. EXPERIMENTAL INVESTIGATION

Past demand data from the retailer and manufacturer for the period of August 2013 to December 2014 (Shown in Table 1) is used to estimate the demand forecast for the period of January 2015 to December 2015. Moving average, simple exponential smoothing and Holt’s forecasting methods are applied to estimate the forecast. Moving average forecast is estimated with 3 periods, 4 periods and 5 periods moving averages. Exponential smoothing forecast also estimated with different smoothing constants ($\alpha=0.1, \beta=0.2$ and $\alpha=0.3$). Further, the Holt’s forecast method used with different smoothing constants for level ($\alpha$) and smoothing constants for trend ($\beta$) i.e. ($\alpha=0.1, \beta=0.1$, $\alpha=0.2, \beta=0.2$ and $\alpha=0.3, \beta=0.3$). All the forecast values related to retailer and manufacturer are displayed in the Table 2 and Table 3 respectively. Bullwhip effect and order rate variance ratio are estimated from the forecast estimation for the period from January 2015 to December 2015 and actual order from the customer for the period of January 2015 to December 2015. The relation for the Bullwhip effect and order rate variance ratio for the retailer and manufacturer are given in the equation 1 to 4.

\[
BUE_{(Retailer)} = \frac{\text{Variance of the order}}{\text{Variance of the retailer forecast}} - -(1)
\]

\[
BUE_{(Manufacturer)} = \frac{\text{Variance of the order}}{\text{Variance of the manufacturer forecast}} - -(2)
\]

\[
OBVR_{Retailer} = \frac{\text{Variance of the order} \times [\text{Average of the order}]}{\text{Variance of the Retailer forecast} \times [\text{Average of the Retailer forecast}]} - -(3)
\]

\[
BUE_{(Manufacturer)} = \frac{\text{Variance of the order} \times [\text{Average of the order}]}{\text{Variance of the Manufacturer forecast} \times [\text{Average of the manufacturer forecast}]} - -(4)
\]

Table 1: Retailer demand, manufacturer demand and customer order

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Retailer Demand</th>
<th>Manufacturer demand</th>
<th>Year</th>
<th>Month</th>
<th>Customer order</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Aug</td>
<td>975</td>
<td>1005</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
<tr>
<td></td>
<td>Sep</td>
<td>1085</td>
<td>950</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
<tr>
<td></td>
<td>Oct</td>
<td>920</td>
<td>870</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
<tr>
<td></td>
<td>Nov</td>
<td>1025</td>
<td>1020</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
<tr>
<td></td>
<td>Dec</td>
<td>920</td>
<td>940</td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
</tr>
<tr>
<td>2015</td>
<td>Jan</td>
<td>855</td>
<td>1050</td>
<td>2015</td>
<td>Jan</td>
<td>970</td>
</tr>
<tr>
<td></td>
<td>Feb</td>
<td>925</td>
<td>930</td>
<td>2015</td>
<td>Feb</td>
<td>890</td>
</tr>
<tr>
<td></td>
<td>Mar</td>
<td>1125</td>
<td>850</td>
<td>2015</td>
<td>Mar</td>
<td>1100</td>
</tr>
<tr>
<td></td>
<td>Apr</td>
<td>1080</td>
<td>1020</td>
<td>2015</td>
<td>Apr</td>
<td>930</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>1200</td>
<td>1230</td>
<td>2015</td>
<td>May</td>
<td>1170</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>1010</td>
<td>1050</td>
<td>2015</td>
<td>June</td>
<td>960</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>890</td>
<td>1010</td>
<td>2015</td>
<td>July</td>
<td>940</td>
</tr>
<tr>
<td></td>
<td>Aug</td>
<td>930</td>
<td>870</td>
<td>2015</td>
<td>Aug</td>
<td>850</td>
</tr>
<tr>
<td></td>
<td>Sep</td>
<td>1160</td>
<td>945</td>
<td>2015</td>
<td>Sep</td>
<td>1120</td>
</tr>
<tr>
<td></td>
<td>Oct</td>
<td>890</td>
<td>875</td>
<td>2015</td>
<td>Oct</td>
<td>920</td>
</tr>
<tr>
<td></td>
<td>Nov</td>
<td>975</td>
<td>1035</td>
<td>2015</td>
<td>Nov</td>
<td>1020</td>
</tr>
<tr>
<td></td>
<td>Dec</td>
<td>880</td>
<td>1130</td>
<td>2015</td>
<td>Dec</td>
<td>940</td>
</tr>
</tbody>
</table>
IV. RESULT AND DISCUSSION

The impact of the moving period on the bullwhip effect is shown in figure 2. Bullwhip effect increases by increasing the number of moving period for both stage of the supply chain. It is due to the fact that the longer duration in moving period or lead time induces the variability in the demand. The Figure 2, the bullwhip effect at manufacturing entity is relatively more than the retailer entity. Figure 3 depicts the influence of the moving period on the order rate variance ratio. Increase in moving period, the increase the bullwhip effect. It may be noticed from the figure 3, the order rate variance ratio is more at the retailer end when compared to the factory. Figure 4 indicates that, the impact of the smoothing constant on bullwhip effect. It is also observed.

From the figure 4, the bullwhip effect is reduced when increasing the value of the smoothing constant. Bullwhip effect at the retailer entity less than manufacturer entity when α = 0.1 and β = 0.2, whereas at α = 0.3 the manufacturer entity have more bullwhip effect than retailer.

It is observed from the figure 5, the order rate variance ratio also indicate the similar observation made by the bullwhip effect.

Figure 6 shows the effect of smoothing constants (α and β) in the Holt’s forecast method on bullwhip effect. The increase in smoothing constants (α and β) reduce the bullwhip effect. The figure 6 also disclose that, the bullwhip effect at manufacturing entity is more than the retailer stage when α = 0.1 and β = 0.1. For, other values of smoothing constants, the Bullwhip effect at retailer end is more when compared to the manufacturer end. In figure 7, the order rate variance ratio also reflects the same observation.
Impact of forecasting method on bullwhip effect is illustrated in the figure 8. The moving average method yields minimal bullwhip effect than the other methods. Higher bullwhip effect is recorded, when using the exponential smoothing forecast method with the smoothing constant of $\alpha=0.1$. Holt’s forecasting method with $\alpha=0.3$ and $\beta=0.3$. Gives the minimal bullwhip effect than the 3 period moving average method. Figure 9, also express similar indication like bullwhip effect.
V. CONCLUSION

From the experimental investigation the following conclusions are drawn. Moving average, simple exponential smoothing and Holt’s forecasting methods are applied and the forecast with different factors are estimated. Bullwhip effect increases by increasing the number of moving period for both stage of the supply chain and the bullwhip effect at manufacturing entity is relatively more than the retailer entity. The bullwhip effect is reduced when increasing the value of the smoothing constant. Increase in smoothing constants (α and β) reduce the bullwhip effect while using Holt’s method. The moving average method yields minimal bullwhip effect than the other methods. Higher bullwhip effect is recorded, when using the exponential smoothing forecast method with the smoothing constant of α=0.1. Holt’s forecasting method with α=0.3 and β=0.3 gives the minimal bullwhip effect than the 3 period moving average method. Order rate variance ratio also gives similar observation like bullwhip effect in the entire investigation. The present study outlines scope to reduce the bullwhip effect, but not eliminate the bullwhip effect. This preliminary study directs the future work like the evaluation of net stock amplification and inventory performance. Investigation effect of bullwhip effect, when extending the stage of supply chain could be an interesting area of further research.

REFERENCES