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Causes and consequences of bullwhip effect on the boutique industry of Dhaka city

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A B S T R A C T

The phenomenon of the bullwhip effect (BWE) has become a pressing concern in contemporary supply chain management. Every echelon of the supply chain faces the negative consequences of BWE somehow. So, it is crucial to determine the reasons responsible for the BWE to mitigate the consequences. The boutique industry in Bangladesh is a rapidly growing industrial sector. In this study, we focused on finding the reasons and consequences of the bullwhip effect on the boutique industry in Dhaka city. The main targets of this study are to examine the underlying reasons for the BWE, identify the most significant causes from the perspective of Dhaka city, and determine the major consequences of the bullwhip effect. Studies of previous literature and consultation with experts have identified sixteen common causes behind the bullwhip effect. This study uses a survey-based method; respondents are chosen through clustered sampling. Necessary data have been collected with a semi-organized inquiry form. Among all the 16 causes, six causes are found to be the most significant causes from the perspective of retailers and wholesalers. SPSS Version 26 has been used for statistical analysis to make the final decision. We also found ten consequences commonly faced by these two echelons of the boutiques' supply chain because of the bullwhip effect. These are high inventory costs, workforce wastages and higher labor costs, higher replenishment lead-time, higher transportation costs, tension in the buyer-supplier relationship, product unavailability, loss of profit, poor customer service, etc.

1. Introduction

Bangladesh's boutique fashion business has risen swiftly and becomes an essential economic element. Many boutique stores in our country provide a wide variety of products to meet the local demand for apparel. Boutique house manufacturing extends to various product tiers combined into a single product line. Productions have ramifications for both operations and marketing. The producer provides items to satisfy the requirements of merchants and customers. As a result, the boutique fashion business has a wide range of products, short product life cycles, volatile market demand, and stringent supply methods (Şen, 2008). All boutique industries have a particular supply chain management of its own. A supply chain involves all parties directly or indirectly fulfilling customer requests. Not only the suppliers and customers, but recent interest in supply chain management also centers around harmonization among various supply chain members comprising producers, traders, dealers, and sellers. A critical instrument for coordinating a supply chain is through the control of information that flows within the participants. This information flow directly impacts individual supply chain members' product scheduling, inventory control, and delivery plans (Lee et al., 1997). This information flow sometimes has some distortions, called the "bullwhip effect". The bullwhip effect refers to the phenomenon where minor fluctuations in customer demand can

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significantly magnify the orders placed by upstream players, such as manufacturers and wholesalers, as the demand signal propagates along the supply chain. The terminology bullwhip effect was first coined by Proctor and Gamble's logistic executives (Lee et al., 1997).

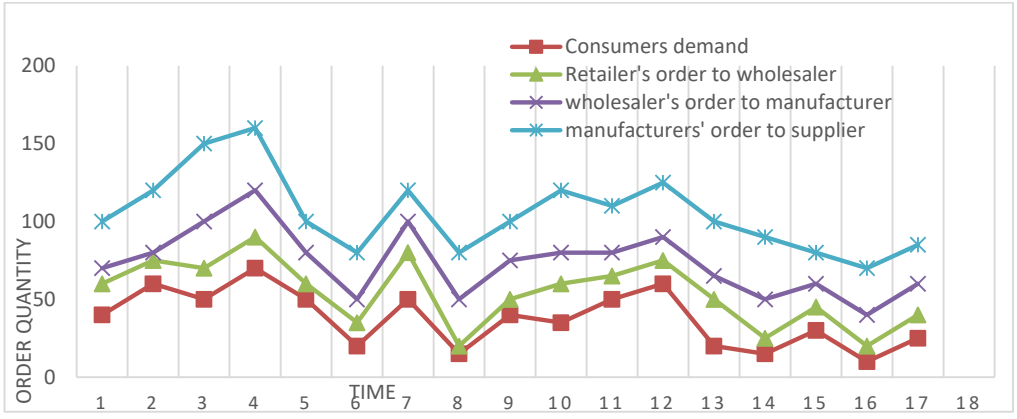

Fig. 1. Order variability during different times.

The study focuses on

- ✓ To identify the causes of the bullwhip effect.
- ✓ To evaluate which causes are more influential on the bullwhip effect for the selected cluster of boutique industry in Dhaka.
- ✓ To identify the consequences of the bullwhip effect for the boutique sector.

2. Literature Review

Bullwhip has recently been acknowledged in a variety of areas. In parallel to P&G and HP, Bristol-Myers Squibb and the pharmaceuticals and retail industries of Wal-Mart experienced a similar occurrence (Handfield et al. 2002). Wang et al. (2005) showed that the most prevalent problem in supply networks is information distortion, often acknowledged as the bullwhip effect. They also proposed an innovative name, "extended bullwhip effect," that is induced by unknown factors. They indicated several origins of the prolonged bullwhip effect, including artificial and physical factors. They also demonstrated some elements that contribute to the prolonged bullwhip effect, including product attributes, decision-maker characteristics, supplier quality, supply chain management characteristics, and microscopical policies. They also classified these factors into internal and external categories (Wang et al., 2005).

Agrawal et al. (2009) and Chatfield et al. (2004) recommended, respectively, to shorten lead times, minimize variance, and restrict increasing order disturbances. Some studies, like Chen and Lee (2009) and Springer and Kim (2010), proposed replenishment strategies as the source of the bullwhip effect.

Giard and Sali (2013) explored demand fluctuation and are primarily concerned with analyzing standardized items of the customer end where current demand and management techniques are applicable. This research found that the SC structure can cause a disturbance between production and selling. According to Sucky (2009), the SC structure is a component that either aggravates or mitigates the BWE.

Khan et al. (2019) exploited beer games to explain the bullwhip effect from a human perspective. This research demonstrates that human actions contribute to the improvement of BWE, exhibiting a reliable connection between the variables being studied. The big five inventory was employed to assess respondents' personality characteristics. This study evaluated five broad qualities as independent factors: responsiveness, social competence, self - confidence, emotional stability, and psychopathy, while stock levels charge, order status expense, and volatility spillover impact (Quantified) were analyzed as the response variable. Disney et al. (2008) conducted a study on two-echelon supply chains and found that BWE can be enhanced due to a lack of coordination between the echelon. Their findings are based on four collaboration schemes: naive functioning, localized enhancement, international improvement, and philanthropic behavior on the part of retailers.

3. Sources of bullwhip effect

The origins of the BWE can be categorized into two groups. They are (i) operational sources, (ii) behavioral sources.

The sources of operational issues are like below:

1. Prediction of demand, 2. Grouping of orders, 3. Price variation, 4. Shortage gaming and rationing, 5. Replenishment policy, 6. Inventory policy, 7. Lead time. 8. Lack of transparency, 9. Improper control system, 10. Deficiency of harmonization, 11. Confusion of response, 12. Number of echelons, 13. Multiplier Effect, 14. Capacity limits, 15. Company processes

Lee et al. (1997) pointed out that the dealings between two coherent echelons in a supply chain are similarly a factor behind bullwhip effect. Behavioral sources include fear of empty stocks.

Causes	Authors of Literature
Prediction of demand	Lee et al. (1997), Mahajan et al. (1990), Chaharsooghi et al. (2008), Hosoda and Disney (2004)
Grouping of orders	Warburton and Disney (2007), Cachon and Lariviere (1999), Cachon and Fisher (2000), Holland and Sodhi (2004), Pujawan (2004)
Price variation	Svensson G (2003), Hamister and Suresh (2008) Mujaj et al. (2007)
Shortage gaming and rationing	Paik and Bagchi (2007), Dejonckheere et al. (2002), Liang and Huang (2006)
Replenishment Policy	Jakšič and Rusjan (2008), Boute (2007), Lee and Wu (2006)
Inventory Policy	Hoberg et al. (2007), Clark and Scarf (2004), Aharon et al. (2009)
Lead Time	Liao and Shyu (1993), Ben-Daya and Raouf (1994), Higuchi and Troutt (2004)
Lack of transparency	Viswanathan et al. (2007), Zhao and Wang (2008), Sohn and Lim (2008)
Improper Control System	Heydari et al. (2009), Huang and Liu (2008), Alwan et al. (2003)
Deficiency of harmonization	Hamister and Suresh (2008) Mujaj et al. (2007)
Confusion of response	Thonemann (2002)
Capacity limit	Jakšič and Rusjan (2008), Huang and Liu (2008), Alwan et al. (2003)
Multiplier effect	Geary et al. (2006)
Number of echelon	Liang and Huang (2006), Aharon et al. (2009)
Fear of empty stocks	Lee et al. (1997), Chandra and Grabis (2005)

4. Consequences of bullwhip effect

In several research we found some consequences due to the bullwhip effect. The most common consequences are given below:

1. Excessive inventory cost (Lee et al., 1997; Chopra & Meindl, 2005)
2. Higher Manufacturing Cost (Lee et al., 1997; Leedy & Ormrod, 2001)
3. Insufficient capacity (Sun & Ren, 2005)
4. Product unavailability (Heydari et al., 2009; Chopra & Meindl, 2005)
5. Manpower wastage and higher labor cost (Chopra & Meindl, 2005)
6. Poor customer service & loss of goodwill (Lee et al., 1997)
7. Tense buyer supplier relationship (Chopra & Meindl, 2005)
8. Higher transportation cost (Chopra & Meindl, 2005)
9. Higher replenishment lead time (Heydari et al., 2009)
10. Loss of profit

5. Research Methodology

Among the several approaches in quantitative research like content analysis, experiment, use of secondary data and survey method, a structured questionnaire-based survey approach is employed in this study. Data from the boutique industry is collected from both the retailer and wholesalers point of view.

5.1 Data Analysis and Findings

Reliability of reasons behind the BWE is testified by the use of Cronbach's alpha value.

Reliability statistics of retailers' opinion

Cronbach's Alpha	No of Item
0.661	15

Reliability statistics of wholesales opinion

Cronbach's Alpha	No of Item
0.655	16

Table 1 indicates that 'α' coefficient of the fifteen variables is 0.661, which implies that these variables possess a reasonably strong consistency (internal). Similarly, Table 2 demonstrates that the 'α' coefficient of the sixteen variable quantity is 00655, suggesting that these variables exhibit good consistency.

Fig. 2 represents the assessment of the reasons of identified sources (based on the retailer's point of view) behind the bullwhip effect (sample size, n is 100).

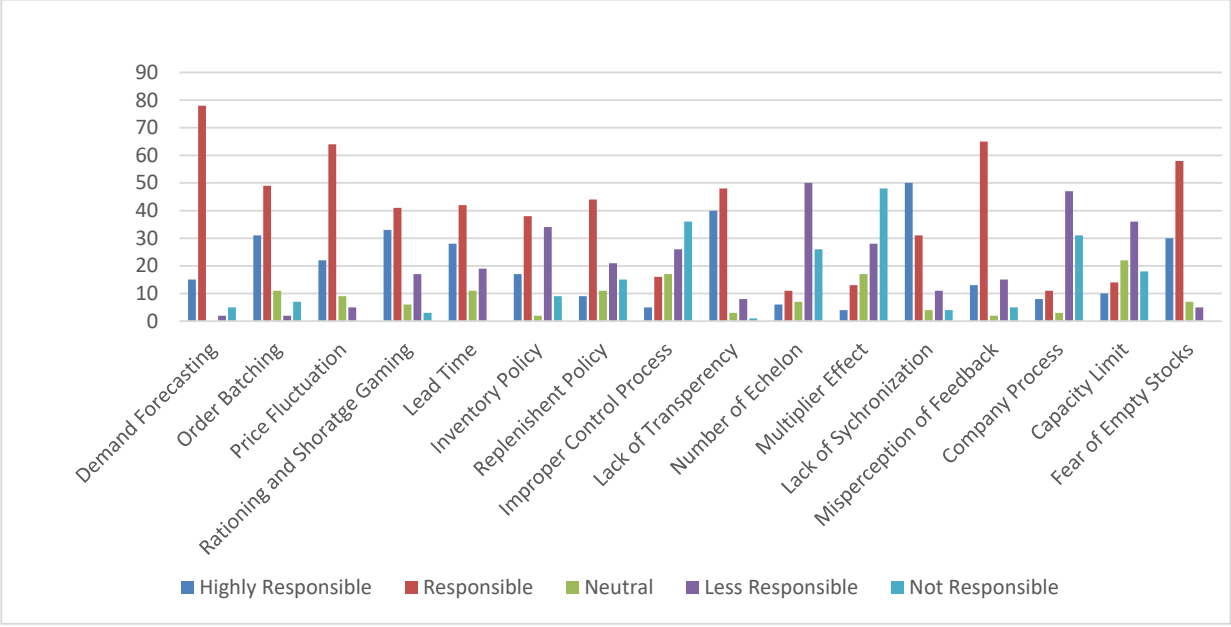

Fig. 2. Causes of bullwhip effect from retailer's point of view.

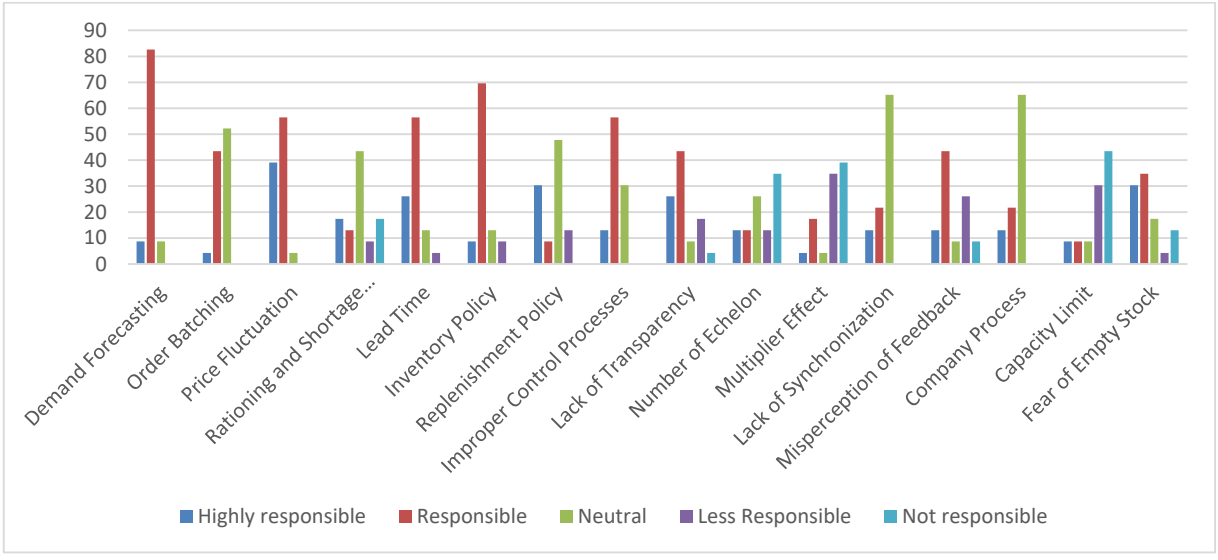

Fig. 3. Causes of bullwhip effect from wholesaler's point of view**.**

5.2 Cross Tabulation

Cross tabulation is performed to check dependencies between two variables. If the value of P of the Pearson χ^2 exceeds 0.05, then there will be dependency between those variables. Here we studied the dependencies between each cause and the bullwhip effect (Qualtricks, 2021). Cross tabulation between the causes and bullwhip effect has been analyzed to find the dependence among these.

Table 3
KMO and Barlett's test

Kaiser-Meyer-Olkin and Barlett's test		
KMO Ration of the appropriateness of the sample.		0.540
Barlett's sphericity test	χ^2 (Approximate)	161.741
	df	120
	Significance	0.007

5.3 Correlation among the variables

Pearson correlation is used to analyze the interrelationships between variables, specifically to determine the degree of correlation between them (causes). A positive correlation occurs when both variables increase simultaneously, meaning that higher mathematical values in one variable correspond to higher numerical values in the other. A negative correlation arises when one drops as another grows, i.e. when one variable's high numerical values correspond to the small mathematical values of the other. We know that the Pearson correlation value should be between +1 and -1.

6. Factor Analysis (for Wholesalers)

The value is 0.540 which is greater than 0.5 (not standard but acceptable). When the P-value in Barlett's test for Sphericity is below 0.05, it indicates a strong indication that the variables are meaningfully associated with each other.

Table 4
Communalities for factor analysis

	Initial	Extraction
Demand Forecasting	1.000	0.700
Order Batching	1.000	0.786
Price Fluctuation	1.000	0.749
Rationing and Shortage Gaming	1.000	0.935
Lead Time	1.000	0.883
Inventory Policy	1.000	0.742
Replenishment Policy	1.000	0.705
Improper Control Processes	1.000	0.731
Lack of Transparency	1.000	0.566
Number of Echelon	1.000	0.720
Multiplier Effect	1.000	0.874
Deficiency of harmonization	1.000	0.688
Confusion of response	1.000	0.724
Company Process	1.000	0.527
Capacity Limit	1.000	0.880
Fear of Empty Stock	1.000	0.674

Drawing out Process: Prime Element Exploration.

In Table 4, it is shown that all 16 causes have communalities value greater than 0.5 for wholesalers' data. So, all these causes are relatively important on the perspective of wholesalers.

6.1. Factor Analysis (Retailers)

KMO test is used to assess the adequacy of the sampling in a study. The value is 0.556 which is greater than 0.5 (standard value of factor analysis).

Table 5
KMO and Bartlett's test

KMO Ration of Sampling Appropriateness		0.556
Bartlett's sphericity test	Approx. χ^2	118.679
	df	78
	Signicance	0.002

Table 6
Communalities for factor analysis

	Initial	Extracted
Demand Forecasting	1.000	0.632
Order Batching	1.000	0.622
Price Fluctuation	1.000	0.612
Inventory Policy	1.000	0.776
Replenishment Policy	1.000	0.760
Improper Control Processes	1.000	0.714
Lack of Transparency	1.000	0.691
Number of Echelon	1.000	0.589
Multiplier Effect	1.000	0.590
Confusion of response	1.000	0.562
Company Process	1.000	0.545
Capacity Limit	1.000	0.712
Fear of Empty Stock	1.000	0.562

Method Extracted: Primary Factor Examination.

Table 6 represents that each factor has loading greater than 0.5, which suggests their accuracy valid for factor analysis. According to thumb rule variables having factor loading in communalities less than 0.5 explain less than 50% of total variance. So, these variables can be considered as least significant. Here, lead time, rationing and shortage gaming & lack of synchronization are eliminated as their factor loadings are less than 0.5. Principle components analysis with varimax orthogonal rotation is used to reduce a total of 16 causes into 13 causes which are relatively more responsible for bullwhip effect.

6.1.1. Principal Element Examination

The principal element examination aims to decrease a big collection of variables in the small set, which retains most of the information in the large set. The principle component analysis approach allows us to construct and use a smaller collection of variables known as main factors. In this technique "Total Variance Explained Table" has been used to develop several components as the main causes in which all 13 causes are grouped those obtained from communalities value previously.

Table 7
Rotated Element Matrix

	Component					
	1	2	3	4	5	6
Demand Forecast	0.737					
Price Fluctuation	0.602					
Order Batching	-0.508					
Lack of Transparency		0.761				
Fear of Empty Stock		0.635				
Confusion of response		0.628				
Capacity Limit			.838			
Number of Echelon			.539			
Improper Control Process				0.807		
Company Process				0.556		
Replenishment Policy					0.831	
Inventory Policy					0.809.	
Multiplier Effect						0.641

Extraction Process: Major Element Examination.
Process of Rotation: Varimax with Kaiser Normalization.[a]
a. Rotation comes together in 17 repetitions.

6.1.2. Rotated component matrix

Now the obtained components must be named based on which variable or cause load high with which factor. Variables that carry a significant load are indicative of what the factor is measuring or suggesting. We examine each variable closely, analyzing what it measures and identifying any commonalities among them. That is the proper name for the component. The following are the named six components, that are responsible for the bullwhip effect according to the retailers' point of view.

The components are named based on the causes or variables associated with them, and the numeric values assigned to each variable represent its contribution to the formation of the components.

1. Prediction of Ordering Quantities: Demand forecasting (0.737), price fluctuation (0.602) and order batching (-0.508) can be termed as prediction of ordering quantities. Among these elements demand forecasting and price fluctuation explains the largest correlation with this factor, as the demand of customer or how amount of product customer will order can be changed according to the fluctuation of the price of that product, so these causes explain highest contribution to this factor.

1. ***Information Lacking:*** Lack of transparency (0.761), fear of empty stock (0.635), confusion of response (0.628) can be termed as information lacking. The factor is primarily formed by a lack of transparency, indicating that there needs to be greater transparency among the echelon. Insufficient transparency shows the highest contributing element to information lacking. This is called information lacking because the causes grouped into this component are related to the flow of information.
2. ***Limitation of Echelon****:* Capacity limit (0.838) and number of echelons (0.539) are termed as limitation of echelon. Capacity limit is the most contributing element to this component explaining the largest correlation with this component.
3. ***Company's Strategy:*** Improper control process (0.809) and company process (.556) can be termed as company's process. The most significant contributor to this factor is an inadequate control process, which exhibits the highest correlation with this element. This cause is termed "Company Strategy" as all the components in this issue are related to the strategies that a company implements.
4. ***Ordering Policy:*** Replenishment policy (0.831) and inventory policy (0.809) can be termed as the ordering policy. These two causes or elements are almost equally contributing to this factor. Both elements indicate how and in which way the company order product from their supplier, that's why this component named as ordering policy.
5. ***Multiplier Effect:*** As in this factor there is single element only which is multiplier factor (0.641). So, it is named as same as the element.

6.1.3. Scree plot

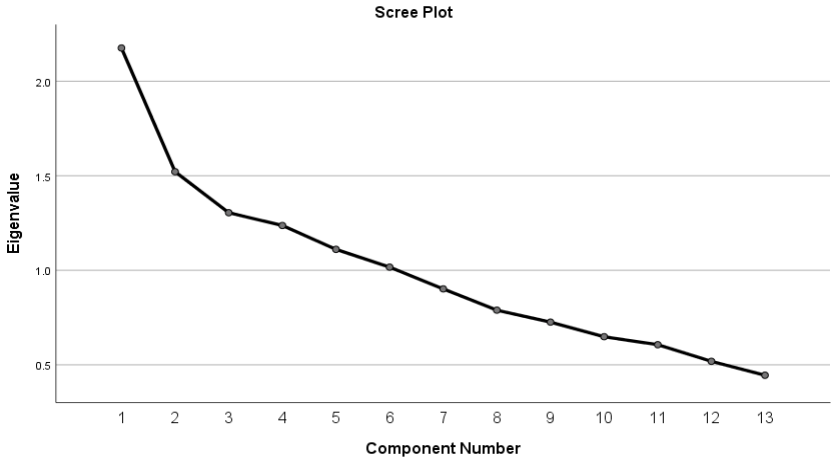

Fig. 4. Scree plot.

From Fig. 4 it is noticed that the 1st elbow occurs on point 3 in the curve. So it can be concluded that 1st 2 components that are explained before are the most influencing factor in bullwhip effect. From table we found demand forecasting, price fluctuation and order batching grouped in 1st components as the name of ordering pattern and fear of empty stock, lack of transparency and misperception of feedback are grouped in 2nd component with the name information lacking. Therefore, it can be concluded these three causes are the most influencing in bullwhip effect.

6.2. Principal component analysis (for wholesalers' data)

Table 8
Explanation of Overall Variance

Element	Eigen Values (Initial)			Extracted summation of Square off loadings			Rotation summations of square off loadings		
	Total	% of Variance	Summative %	Total	% of deviance	Summative%	Total	% of deviance	Summative%
1	2.894	18.086	18.086	2.894	18.086	18.086	2.246	14.036	14.036
2	2.694	16.840	34.925	2.694	16.840	34.925	2.142	13.388	27.424
3	2.296	14.350	49.276	2.296	14.350	49.276	2.066	12.915	40.339
4	1.742	10.888	60.164	1.742	10.888	60.164	2.061	12.883	53.222
5	1.211	7.566	67.730	1.211	7.566	67.730	1.905	11.904	65.125
6	1.045	6.532	74.262	1.045	6.532	74.262	1.462	9.137	74.262
7	0.916	5.728	79.990						
8	0.775	4.841	84.830						
9	0.640	4.000	88.830						
10	0.549	3.431	92.262						
11	0.474	2.962	95.224						
12	0.349	2.182	97.406						
13	0.218	1.365	98.771						
14	0.110	0.688	99.459						
15	0.074	0.462	99.921						
16	0.013	0.079	100.000						

Extraction Method: Principal Component Analysis.

6.3. SCREE PLOT (Wholesalers)

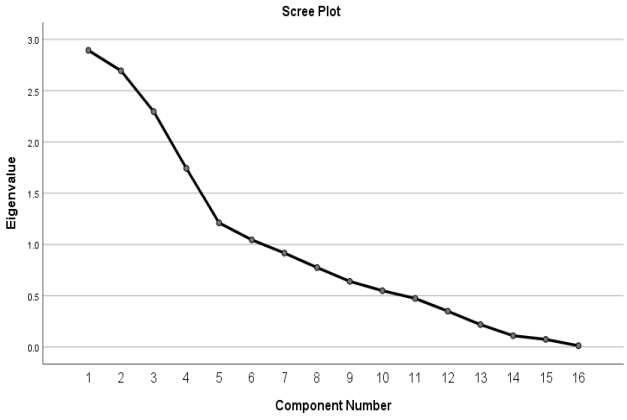

Fig. 5. Sree plot (Wholesalers)

Here the 1st elbow in scree plot occurs at point 5 as shown in figure 5. So according to thumb rule we should extract 4 factors that mostly influence bullwhip effect (The Analysis Factor, 2021)

6.4. Regression Analysis

Regression analysis is the process of estimating the dependency of one variable (dependent variable) on one or more other variables (independent variable). Regression analysis is performed to see how much the bullwhip effect is affected by the six groups or components. Considering overall bullwhip effect as the dependent variable and prediction of ordering quantities, information lacking, limitation of echelons, company's strategy, ordering policy and multiplier effect as the independent variable the regression model is generated like below:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots.. + \beta_p X_p + \mathcal{E}$

Note: X_j are the independent variables

Y be dependent variable

β_0 be the regression constant

β_j are coefficients of regression of independent variable

$\mathcal{E}$ means the term of error

6.4.1. Significance Of The Model

Table 9
Model Implications

Model	R	R^2	Adj. R^2	Standard inaccuracy of estimation
1	0.794[a]	0.630	0.622	0.646743

a. Predictors: (Constant)**,** prediction of ordering quantities, information lacking
b. Dependent Variable: Bullwhip Effect

This represents the model summary of regression analysis. In this table R is the multiple correlation coefficients. The correlation coefficient R values 0.794, indicating a relatively strong positive connection between the predictor variables and the bullwhip effect. Coefficient of determination (R^2) is 0.630 that suggests that 63.0% of the overall deviation in the bullwhip effect can be explained by the predictor variables.

6.4.2 Analysis of Variance

Table 10
ANOVA

	Model	Summation of squares	df	Mean^2	F	Significance
1	Regression	69.067	2	34.533	82.561	0.000[b]
	Residual	40.572	97	0.4182		
	Total	109.64	99			

a. Dependent Variable: Bullwhip Effect
b. Predictors: (Constant), prediction of ordering quantities, information lacking

Table 10, known as the ANOVA table, contains an F-ratio that assesses the suitability of the regression model for the given data. According to table 10, the independent variables significantly predict the dependent variable, as evidenced by a significant F-ratio of 82.561, represented as (2, 97), p-value lower than 0.05. Consequently, the model is deemed to be an appropriate fit for the data .

6.4.3. Coefficient

The regression coefficient's significant p-values indicate that all variables, except for "information lacking," have a significant influence on the bullwhip effect.

Table 11
The coefficients

Model	Nonstandardized coefficients		Standardized coefficients		
	B	Standard Error	Beta	t	Sig.
Constant	0.033	0.319		0.103	0.918
Prediction of Ordering Quantities	0.480	0.066	0.466	7.301	0.000
Information Lacking	0.600	0.071	0.537	8.420	0.000

Unstandardized coefficients in a regression model are the estimates of the model parameters obtained through ordinary least squares. They provide a direct measure of the connection between variables (independent and dependent) in the original units of measurement. Now the estimated regression line can be written as:

Y= 0.0333-0.480* Prediction of Ordering Quantities* +0.600*Information Lacking + error term
Y= Bullwhip Effect

7. Consequences of bullwhip effect

The frequency of each consequence is shown in this chart. The main consequences of bullwhip effect are excessive inventory cost, manufacturing cost, insufficient capacity, product unavailability, poor customer service and loss of good will, higher transportation cost, tense in buyer supplier relationship higher replenishment lead time, loss of profit.

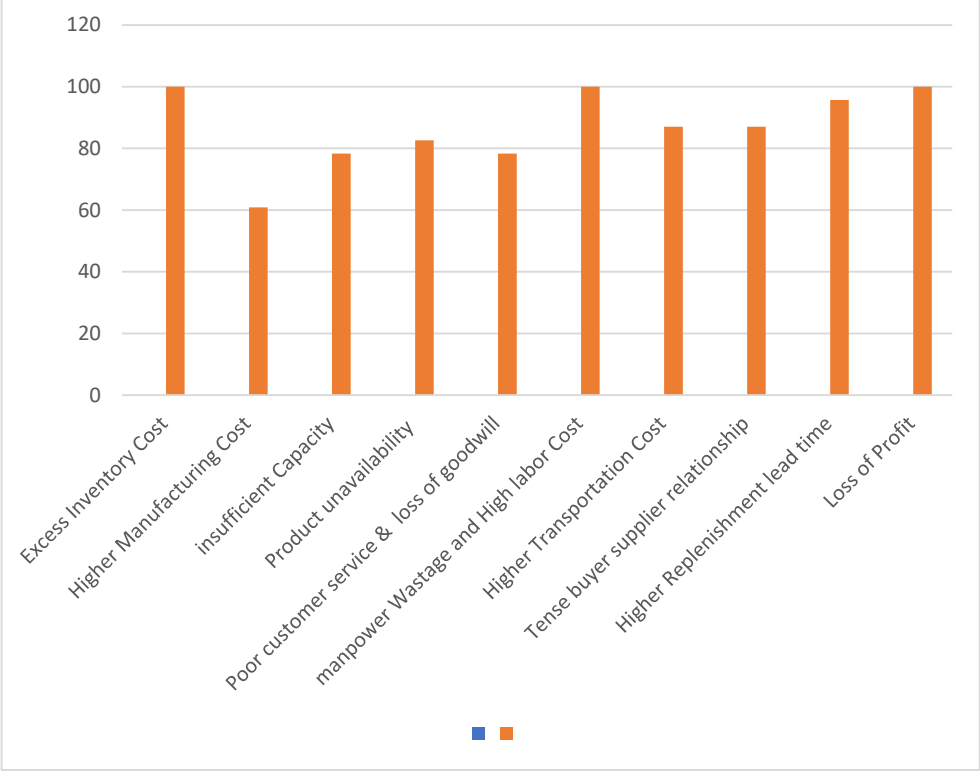

Fig. 6. Consequences those boutique industries face due to bullwhip effect

8. Discussion and conclusion

From analysis the statistical tool and quality control tool both have common six reasons that are mostly liable for bullwhip effect.

Significant reasons after analysis

Retailer's Opinion	
Statistical Analysis	Demand Forecast, Price Fluctuation, Order Batching, Lack of Transparency, Fear of Empty Stock, Confusion of response, Capacity Limit, Number of Echelon, Improper Control Process, Company Process, Replenishment Policy, Inventory Policy, Multiplier Effect
Wholesaler's Opinion	
Statistical Analysis	Demand Forecasting, Multiplier Effect, Number Of Echelon, Price Fluctuation, Order Batching, Rationing And Shortage Gaming, Confusion of response, Fear Of Empty Stock, Lack Of Transparency, Inventory Policy, Replenishment Policy, Improper, Control Processes, Deficiency of harmonization, Capacity Limit, Company Process, Lead Time

The study aimed to find out the most significant causes of the bullwhip effect on the boutique industry in Dhaka city. After reviewing several literatures, sixteen causes are found that are in charge of bullwhip effect. Among them few common causes are found which are identified as very much liable for bullwhip effect in case of both retailers and wholesalers' responses such as demand forecasting, price fluctuation, order batching, fear of empty stock, lack of transparency and misperception of feedback. This study also showed what types of consequences they face due to bullwhip effect such as excessive inventory cost, higher manufacturing cost, insufficient capacity, product unavailability, poor customer service, higher labor cost and manpower wastage, higher transportation cost, tense in buyer supplier relationship, higher replenishment lead time and loss of profit.

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