THE IMPACT OF IMPORTANT CONTEXTUAL FACTORS ON 'INFORMATION QUALITY' AS A SUPPLY CHAIN MANAGEMENT PRACTICE

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ABSTRACT

Supply Chain Management (SCM) practices have been defined as a set of activities undertaken in an organization to promote effective management of its Supply Chain (SC). The 'Quality of Information' exchanged between trading partners is one of such constructs (practices) vital for achieving excellence in organizational management. The objectives of the study are to analyze the impact of important contextual factors on 'Information Quality (IQ)' and to recommend the dimensions to be improved for achieving better level of the practice. Data were collected from manufacturing firms of three industries: Apparel, Food and Printing. Industry, Organization Size, SC Length, Channel Structure and Demand Uncertainty were the contextual factors considered. For evaluating IQ, the measurement instrument developed by Suhong Li *et al*. was used. It defines Timeliness, Accuracy, Completeness, Adequacy and Reliability of information as basic dimensions of IQ. The study discovered that Industry, Size of the firm and Downstream SC structure have significant impacts on IQ.

Keywords: Supply Chain Management Practices, Information Quality, Contextual Factors, Manufacturing Firms

1. INTRODUCTION

Poor managerial and employee support, unclear objectives, lack of strategy, corporate culture are the major barriers against SCM implementation (Charles *et al*., 2003). Therefore, understanding the impact of the factors affecting SCM practices would support to overcome these barriers. Organizations exchange several types of information along with their supply chains in numerous ways. All information is not equally important and some waste money, time and other resources that could be used for many purposes. The quality of information received by an organization obviously determines the firm's success in its management of supply chain. The study analyzes the impact of important contextual factors on 'Information Quality (IQ)' as a SCM practice. This will provide a start to comprehensive SCM feasibility assessment, especially for the Sri Lankan manufacturing firms. The contextual factors considered are: Industry, The size of the Firm, Length of the SC, Channel Structure and the Level of Uncertainty in the Demand. For evaluating IQ, the measurement instrument developed by Suhong Li *et al*. (2005) was used. As they define, Information Quality consists of five dimensions: Timeliness, Accuracy, Completeness, Adequacy and Reliability. The data were collected through a questionnaire from 86 randomly selected manufacturing firms of three industries: Apparel, Food and Printing. These industries were selected because a lot of Sri Lankan firms are engaged.

Identifying the impact of a firm's main contextual factors on SCM construct Information Quality will provide a start to comprehensive SCM feasibility assessment, especially for the Sri Lankan manufacturing firms. Therefore, the findings of this study will offer initiatives to start practicing SCM in Sri Lankan manufacturing companies, which are far behind in the global competition. Few firms in Sri Lanka have formally implemented SCM and even they are not based on properly studied compatibility of the practices to the firm's context. Perhaps a failure in IQ is not a failure of all the aspects of the practice. Therefore, it is important to recognize particular aspects (dimensions) of the practice that should be re-considered, in order to improve the overall performance of the practice. Since many of the Sri Lankan manufacturers in these three industries are

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engaging in global trade, the findings will be useful for those firms for SCM improvement.

1.1 Limitations

Since the research covers only manufacturing firms, the findings might not be applicable for the other positions in the supply chain (material suppliers, distributors and retailers). Also, the impact of these contextual factors might be somewhat dissimilar in another country because the sample contained only Sri Lankan firms. As mentioned above, there may be many other external and internal factors influencing SCM practices of a firm that have not been considered here. This research limits the scope, to the main contextual factors which will be important to any manufacturing organization. It was not simple to obtain exact data for these contextual factors, mostly because of the complexity in the SC. The questionnaire could obtain only approximated figures. "Length of the SC" is one of the examples. Since the sample did not contain any service organization, the results cannot be generalized for the service organizations.

2. LITERATURE REVIEW

Supply Chain Management (SCM) practices have been defined as a set of activities undertaken in an organization to promote effective management of its supply chain (Li *et al*., 2005). This research has found six constructs for SCM practices, defining a number of dimensions (attributes) for each construct. The six practices are: Strategic Supplier Partnership, Customer Relationship, Information Sharing, Information Quality, Internal Lean Practices and Postponement. According to them Information Quality has five dimensions: Timeliness, Accuracy, Completeness, Adequacy and Reliability. Charles *et al*., 2003 have mentioned that poor managerial and employee support, unclear objectives, lack of strategy, corporate culture are the major barriers against SCM implementation. Studying the impact of the factors affecting SCM practices would support to overcome these barriers.

The realities of today's digital economy are requiring and enabling dramatically improved levels of SC efficiency and effectiveness. The business-to-business (B2B) or extended digital SC, enabled by Internet technologies, is specifically being offered as the next competitive weapon. McCormack and Kasper, (2002) have offered definitions and measures of the extended SC construct and reviewed the results of an ongoing benchmarking research project completed in cooperation with the US and European Supply Chain Councils. This study found that internet usage is just beginning in both the USA and Europe but has significant relationships to cross-company (B2B) integrating practices that are key components of the extended SC and SCM performance.

Supply chain practices were classified into five broad types (www.ctl.mit.edu):

1. *Supply Chain Integration (SCI)* includes integration with customers, with suppliers, and across the internal organization. From the functional perspective, integrated collaborative product development is also included.
2. *Complexity Management* refers to coping with supply chain complexity in a cost-effective way.
3. *Aligning Strategy and Supply Chain* implies that SCM is well integrated into the strategic planning of a company and its CEO-level agenda.
4. *Information Technology (IT)* with Process Improvement means adoption of advanced SCM software combined with process improvement.
5. *Operational Innovation* means creating and implementing leading-edge practices and technologies in SCM.

The purpose of the research done by Damien (2005) is to review a sample of the literature relating to the integration and implementation of SCM practices from a strategic viewpoint. The literature is examined from three perspectives. First, SC integration covers issues relating to integration of core processes across organizational boundaries through improved communication, partnerships, alliances and cooperation. Second, strategy and planning examines SCM as a strategic matter for trading partners, along with factors relating to the amount of planning required. Third, implementation issues concern factors critical for successful implementation, as well as issues specific to inter and intra-organizational aspects of supply chain initiatives are contained in this sub-group. An important emergent theme from the literature is the importance of taking a holistic view, and the systemic nature of interactions between the participants. At the same time, it is also apparent that this requirement to take such a holistic and systemic view of the SC acts as an impediment to more extensive implementation. The strategic nature of adopting a SC-wide perspective, on the one hand, provides significant potential benefit, and on the other, requires trading partners to think and act strategically. This review of the literature serves to highlight the inter-dependence between integration (technologies, logistics, and partnerships), a strategic view of SC systems, and implementation approach. All three need to inform and underpin each other in order for management of supply chains to be able to deliver on the promise of benefits for all trading partners.

3. METHODOLOGY

The data were collected from a randomly selected sample of manufacturing firms from apparel, food and printing industries. Approximately, an equal number of firms from each industry was selected and 86 firms were covered. The composition of the sample is given in Table 1. A questionnaire was used to collect data.

Table 1: Composition of the Sample

		Size of the Firm			
		Large	**Medium**	**Small**	**Total**
Industry	Apparel	14 (16.3%)	10 (11.6%)	04 (4.7%)	28 (32.6%)
	Food	13 (15.1%)	09 (10.5%)	11 (12.8%)	33 (38.4%)
	Printing	07 (8.1%)	12 (14%)	06 (6.9%)	25 (29%)
	Total	34 (39.5%)	3 (36.1%)	21 (24.4%)	86 (100%)

A formal statistical analysis was performed on data collected using MINITAB 14. This data analysis was basically of three parts: General Linear Model (GLM), Pair-wise Mean Comparison and Spearman's Rank Correlation analysis. The validity of underlying assumptions of the GLM was checked using a proper residual analysis.

3.1 The Supply Chain Evaluation Model

The supply chain evaluation model was used for collecting data has six constructs: Strategic Supplier Partnership, Customer Relationship, Information Sharing, Information Quality, Internal Lean Practices and Postponement. It was conceptualized, developed and validated by Li *et al*. (2005) and Information Quality (IQ) is one of the SCM constructs in this model. As they define, Quality of information exchanged between trading partners is determined by Timeliness, Accuracy, Completeness, Adequacy and Reliability.

3.2 Organizational Contextual Factors

The size of the Firm, Length of the SC, Channel Structure and Level of Uncertainty in the Demand were assumed to be most important contextual factors when implementing SCM at a firm. Definitions for all contextual factors and the justifications to derive the levels of the factors are described below.

- **Industry:**

The three industries considered are: Apparel, Food and Printing. The reason for this selection was that they represent a larger proportion of Sri Lankan Manufacturing companies and their perceived differences in SC characteristics. Even though the 'Printing' industry has a lot of service characteristics, it was also included considering its manufacturing process involved.

- **Size of the Firm:**

An exact definition given by any authorization was not found for the size of the firm and a lot of studies have used the level of income of the company as a major indicator for determining it. Therefore, the annual turnover of the company was used as the basis for classifying the companies into Small, Medium and Large.

- **Length of the SC:**

The total number of participants (estimated) in the upstream and the downstream of the manufacturer was considered as the length of the supply chain. It is not practical to find the actual length of the entire SC because of the complexity. Therefore, it was approximately obtained by classifying the number of upstream and downstream entities as Small, Medium and Large according to the manufacturer's knowledge.

- **Channel Structure:**

The structure of the intermediaries in the supply chain. The upstream and downstream structures were considered in the following manner.

Table 2: Coding for Upstream & Downstream Structures

Raw Material Flow (Upstream)	**Upstream Structure**
Raw material manufacturer → Manufacturing company	Up-Str1
… → Retailer → Manufacturing company	Up-Str2
… → Distributor/ Wholesaler → Manufacturing company	Up-Str3
Finished Product Flow (Downstream)	Downstream Structure
Manufacturing company → End customer	Down-Str1
Manufacturing company → Retailer → End customer	Down-Str2
Manufacturing company → Distributor/Wholesaler → Retailer → End customer	Down-Str3

- **Level of uncertainty in the demand**

How much uncertain the demand for the manufacturer's main product. Uncertainty in the demand was classified into two: Low and High. The level 'Medium' was excluded aiming to reduce the confusion to the respondent when answering.

Table 3: Variables of the Study & the Types of Data

Variable	Type(Scale) of Data
Information Quality (IQ) SC construct	Ordinal/Interval (Likert scale)
Contextual factors:	
1. Size of the firm	Ordinal
2. Length of the SC	Ordinal
3. Channel structure	Nominal
4. Industry	Nominal
5. Level of uncertainty in the demand	Ordinal

The alternative hypotheses formulated are as follows:

H_{1A}: The industry influences on information quality

H_{1B}: Size of the firm influences on information quality

H_{1C}: Length of the firm's SC influences on information quality

H_{1D}: Level of uncertainty in the demand influences on information quality

H_{1E}: Upstream SC structure influences on information quality

H_{1F}: Downstream SC structure influences on information quality

H_{1G}: Industry and size of the firm have a combined effect on information quality

H_{1H}: Industry and length of the firm's SC have a combined effect on information quality

H_{1I}: Industry and level of uncertainty in the demand have a combined effect on information quality

H_{1J}: Upstream and downstream SC structure has a combined effect on information quality

The descriptive analysis results confirmed that the suitable measure of location for the data on IQ construct is the arithmetic mean, as its distribution is approximately symmetric. This analysis was basically three types. They are: General Linear Model (GLM), Pairwise Mean Comparison and Rank Correlation analysis. The dependencies of the SCM practices on contextual factors were tested using a specific Analysis of Variance called 'General Linear Model'. After identifying significant factors, Tukey's Pairwise Comparison was performed to find out which levels of the factors are significantly different. The results of the GLM analysis were validated by a formal residual analysis. In order to make recommendations about the areas to be improved, for achieving better levels of IQ, Spearman's Rank Correlation analysis was performed.

4. DATA ANALYSIS

The p-values corresponding to the GLM analysis performed to identify contextual factors which have significant influence are given in Table 4. (These results were validated and corresponding residual analysis is provided in Appendix)

Table 4: Corresponding P-Values of General Linear Models

Model	Factor	p -Value
GLM1:		
Industry+Size+ Industry*Size	Industry	0.016
	Size	0.756
	Industry*Size	0.006
GLM 2:		
Industry+SC Length+ Industry*SC Length	Industry	0.332
	SC Length	0.712
	Industry*SC Length	1.000
GLM 3:		
Industry+Demand Uncertainty+ Industry+Demand Uncertainty	Industry	0.033
	Demand Uncertainty	0.007
	Industry*Demand Uncertainty	0.181
GLM 4:		
Industry+Size+Demand Uncertainty+Industry*Size + Industry*Demand Uncertainty+Size*Demand Uncertainty[1]	Industry	0.010
	Size	0.749
	Demand Uncertainty	0.196
	Industry*Size	0.023
	Industry*Demand Uncertainty	0.285
	Size*Demand Uncertainty	0.648

([1]Third order interactions were not tested due to absence of a sufficient number of observations for the combinations)

The p-values indicate that Industry and Size of the Firm have an interaction effect on No significant interaction effect of Industry and SC Length and their main effects are also not significant. According to the GLM 3, both Industry and Uncertainty of demand influence IQ. Prior to this, it has been found that the Industry and the Size of the firm jointly influence IQ. Therefore, some factors might have confounding effects which cannot be realized from a GLM with only second order interactions. GLM 4 was obtained by applying a GLM for IQ using factors: Industry,

Size of the firm and the level of uncertainty in demand, including all possible second and third order interaction terms. It clearly shows that Industry and Size have a significant combined effect on IQ and no other terms were found significant.

To further check the interaction effect of the Industry and the Size of the firm, a One-way ANOVA model was applied and the p-value obtained is 0.015. It also implies that there is a significant difference in level of IQ in different combinations of the two contextual factors. The nature of the interaction effect for different combinations of Industry and Size, can be recognized from Figure 1. It shows that the level of IQ is the highest for small scale apparel manufacturers while it is very low for medium scale food manufacturers and small scale printers.

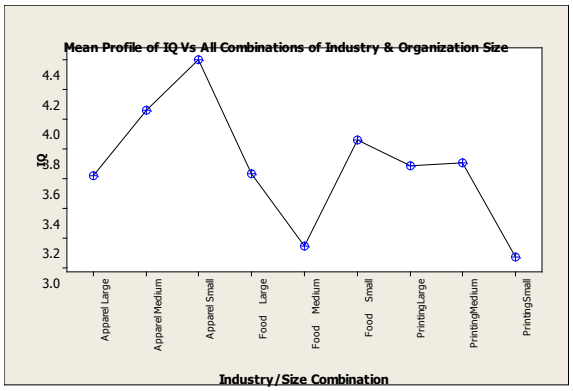

Figure 1: Mean Profile of IQ for All Combinations of Industry & Size of the Firm

Tukey's Pairwise Comparison analysis was performed to identify the combinations of Industry and the Size which receive significantly different levels of IQ. It provided the combinations shown in Table 5.

Table 5: Significant Combinations of Interaction Effect of Industry and Size of the Firm on IQ
(Tukey's Pairwise Comaprison)

i.	Apparel/Medium & Food/Medium
ii.	Apparel/Medium & Printing/Small
iii.	Apparel/Small & Food/Medium
iv.	Apparel/Small & Printing/Small
v.	Food/Small & Food/Medium
vi.	Printing/Medium & Food/Medium
vii.	Food/Small & Printing/Small
viii.	Printing/Medium & Printing/Small

GLM fitted to IQ using Upstream and Downstream SC structures as factors provided the following p-values. It shows that Downstream SC structure has a significant impact on IQ while Upstream structure or interaction of two structures do not have a significant effect.

Table 6:GLM-Factors:Upstream & Downstream SC Structure

Factors	p-Value
Upstream SC Strcture	0.846
Downstream SC Strcture	0.018
Upstream Structure* Downstream Structure	0.147

The main effect plot given by Figure 2 shows that the Downstream Structure 2 (selling the main product through retailers) has the lowest level of IQ.

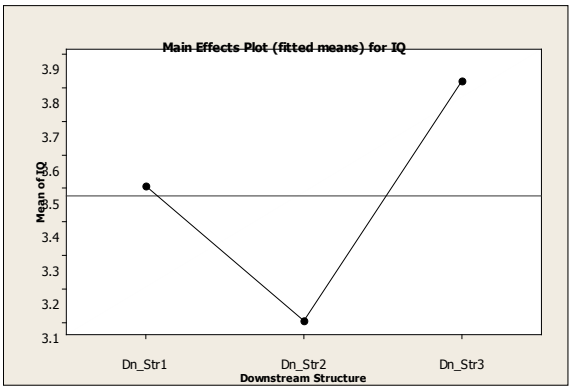

Figure 2: Main Effects Plot for IQ (Downstream SC Structure)

Table 7: Tukey's Pairwise Comaprison for IQ (Factor: Downstream SC Structure)

Factor	Levels	Statistical Significance
Downstream Structure	Down-Str1/ Down-Str2	Not significant
	Down-Str1/ Down-Str3	Not significant
	Down-Str2/ Down-Str3	Significant

According to the results in Table 7, only Down-Str2 and Down-Str3 are significantly different in IQ. That means manufacturers who sell their main product through distributors/wholesalers and retailers tend to exchange better quality information with their trading partners than who sell only through retailers. This might be because they do not recognize IQ as so important when they have lesser partners.

4.1 Correlation Analysis

P-values in Table 4 indicate that there is a significant difference in the level of IQ between different combinations of Industry and the Size of the firm. The combinations selected for the correlation analysis are the combinations which have been selected as significant by Tukey's Pairwise Comparison (Table 5). Table 8 provides the results.

Table 8: Rank Correlation Coefficients with IQ for Combinations of Industry and Size of the Firm

Attribute of IQ[1]	Apparel/ Medium	Apparel/ Small
IQ1(Timeliness)	0.69293	0.86603
IQ2(Accuracy)	0.51795	0.86603
IQ3(Completeness)	0.66144	1.00000
IQ4(Adequacy)	0.84248	0.86603
IQ5(Reliability)	0.92962	0.86603
Attribute of IQ[1]	**Food/ Medium**	**Printing/ Small**
IQ1	0.80296	0.67893
IQ2	0.89912	0.92582
IQ3	*	0.92582
IQ4	0.70244	0.95618
IQ5	0.58835	0.77152
Attribute of IQ[1]	**Food/ Small**	**Printing/ Medium**
IQ1	0.93850	0.93877
IQ2	0.87939	0.83412
IQ3	0.88636	0.62271
IQ4	0.92129	0.65007
IQ5	0.90915	0.34340

Tukey's Comparison result (Table 5) implies that medium scale food manufacturers and small scale printers have significantly a lower level of IQ compared to medium scale printers, medium/small scale apparel and small scale food manufacturers. Mean profile given by Figure 1 also reveals this. The correlation analysis result says that both categories of manufacturers should focus on IQ1 (Timely exchange of information between trading partners) and IQ5 (Reliable exchange of information between trading partners) in order to improve IQ. In addition to that medium scale food manufacturers should also concentrate on IQ4 (Adequacy of information exchanged).

5. CONCLUSIONS

- Industry and the size of the firm have a combined effect on Information Quality.
  - Small scale apparel manufacturers have relatively the highest level of IQ and it is very low in medium scale food manufacturing and small scale printing firms. Mean comparison results of the study implies that medium scale food manufacturers and small scale printers have significantly a lower level of IQ compared to, medium scale printers medium/small scale apparel and small scale food manufacturers.
- Downstream supply chain structure has a significant impact on IQ.
  - Manufacturers who sell their main product through distributors/wholesalers and retailers, tend to exchange better quality information with trading partners than who sell products only through retailers. Even though the reason behind this could not be exactly realized, lack of formalization in information flow might be the prominent cause. Perhaps manufacturers who sell through retailers might not understand the genuine importance of the quality of the information exchanged.
- In order to improve IQ, medium scale food and small scale printing firms should focus on 'Timely' and 'Reliable' exchange of information with trading partners.
  - Therefore, manufacturers of these two types should try to develop fast and reliable ways of communication.
- Medium scale food manufacturers should also concentrate on 'Adequacy of information exchanged'.
  - In the food industry, it is very important to frequently assess if the information received is adequate because of the unpreserved nature of food products. Information from upstream as well as downstream trading partners is equally important for this.

6. DIRECTIONS FOR FURTHER RESEARCH

The research has focused on only three industries and it could be extended to a number of other industries as well. Since this study only covers Information Quality of manufacturers, it would be interesting if a research covers other positions in the supply chain such as raw material suppliers, distributors or wholesalers and retailers. This type of study will facilitate investigation of similarities and dissimilarities in the practice (IQ) of different partners in the SC. A comprehensive investigation of underlying causes for having different impacts of the contextual factors could be focused on in a study. This research has not analyzed higher order interactions between contextual factors because of an inadequate number of observations for the sub categories. If a research could have the same focus with a large enough sample with adequate data points for each sub category, then it might discover different types of relationships

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APPENDIX

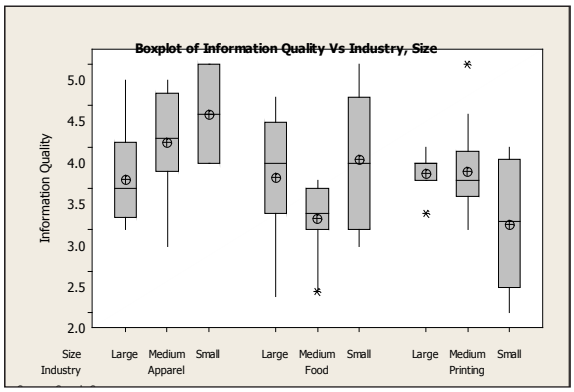

Figure A1: Boxplot of Information Quality Vs Industry, Size

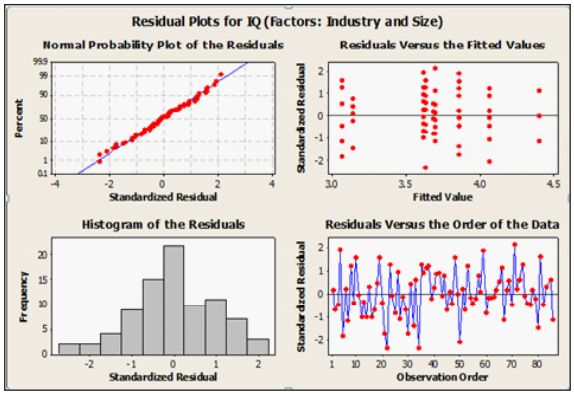

Figure A2: Residual Analysis: IQ Vs Industry, Size

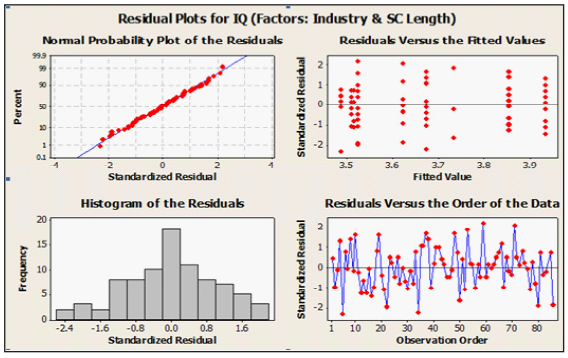

Figure A3: Residual Analysis: IQ Vs Industry, SC Length

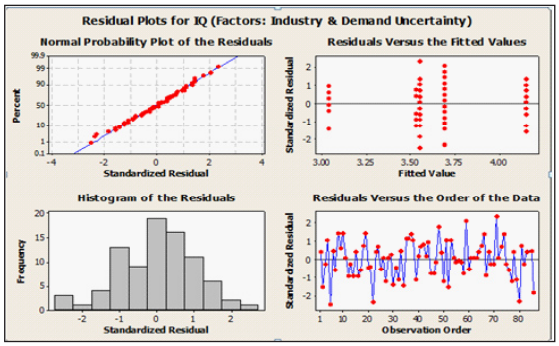

Figure A4: Residual Analysis: IQ Vs Industry, Demand Uncertainty

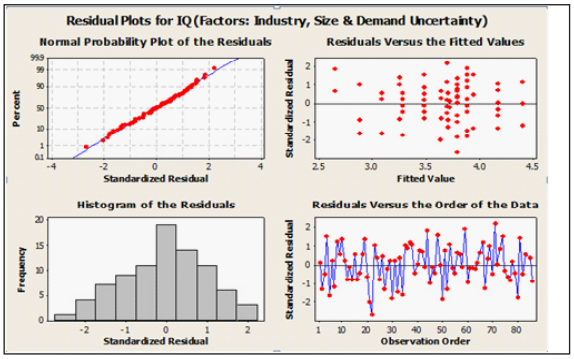

Figure A5: Residual Analysis IQ Vs Industry, Size, Demand Uncertainty

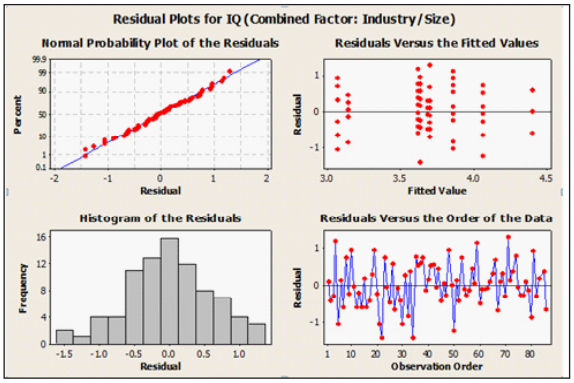

Figure A6: Residual Analysis: IQ Vs Combined Factor: Industry/Size

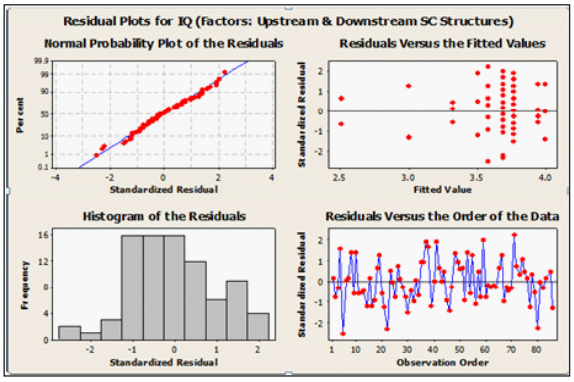

Figure A7: Residual Analysis: IQ Vs Upstream, Downstream SC Structure

Table A1: Normality Test for Residuals

ANOVA Model	P-Value
(Anderson Darling Normality Test)	
General Linear Model (IQ Vs Industry, Size)	0.836
GLM (IQ Vs Industry, SC Length)	0.893
GLM (IQ Vs Industry, Uncertainty in the Demand)	0.787
GLM (IQ Vs Industry, Size, Uncertain-ty in the Demand)	0.934
One-Way ANOVA (All combinations of Industry & Size)	0.836
GLM (IQ Vs Upstream & Downstream SC Structure)	0.453