Modeling interaction between Quality Management and Supply Chain; A New Approach

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Abstract: Supply chain quality management is one of the most fascinating topics in management. This paper has introduced a new approach in measuring the impact of supply chain management on quality management. This paper has introduced two indexes for measuring supply chain and quality management, also this paper has introduced a regression model for interaction between supply chain and quality management. A new approach in this paper is using Calibration and Simulation method for measuring and estimation the parameter of the model. We have used the data of 280 Iranian firms of Tehran Stock Exchange. Simulation Results indicate that supply Chain Index has a significant Positive impact on Quality Management Index.
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1. Introduction

In recent years, there is more attention on supply chain and quality management. This subject introduced as supply chain quality management. Supply chain and quality management are two important factors in every firms or organization.

The term quality management has a specific meaning within many business sectors. This specific definition, which does not aim to assure 'good quality' by the more general definition, but rather to ensure that an organization or product is consistent, can be considered to have four main components: quality planning, quality control, quality assurance and quality improvement [Kenneth (2005)].

Supply chain management (SCM) is the management of a network of interconnected businesses involved in the provision of product and service packages required by the end customers in a supply chain [Harland (1996)].

A better understanding of the distinction between outcome-based and behavior-based approaches helps managers evaluate which approach is best suited to managing the quality of their suppliers. The propositions pertaining to the key factors provide managers with some guidelines about the critical conditions they should consider when building their firm's supply chain quality management system [Zu and Kaynak (2012)].

Having an effective quality management system of a supply chain is essential for maintaining a smooth supply of high quality products and services to customers [Zu and Kaynak (2012)].

There are many methods and approaches in measuring the main factors of supply chain quality management. This paper has introduced a new approach in measuring the impact of supply chain management on quality management. This paper has introduced two indexes for measuring supply chain and quality management, also this paper has introduced a regression model for interaction between supply chain and quality management. A new approach in this paper is using Calibration method for measuring the parameter of the model.

This paper is organized by 5 sectors. The next section is devoted to literature review. Section 3 introduced a new model of this research. Section 4 is devoted to simulation of the model and final section concluded.

2. Review of Literature

Kaynak and Hartley (2008) have investigated how supply chain management-related quality practices lead to improved performance and examined the practices that precede and mediate those relationships. They have replicated and extended the relationships among the QM practices and their effects on firm performance using survey data gathered from firms operating in the U.S. The inclusion of customer focus and supplier quality management in the QM model supported the importance of internal and external integration for quality performance. Implications of the results for researchers and practitioners were discussed, and further research implications were suggested [Kaynak and Hartley (2008)].

Robinson and Malhotra (2005) have defined the concept of supply chain quality management (SCQM), and evaluated its relevance in academic and industrial practice by comprehensively reviewing prior quality and SCM literature in major journals and inductively identifying the themes that emerge within it. In particular, they have taken a more critical look at those published studies that specifically lie at the interface of quality and external SCM, and argued that quality practices must advance from traditional

firm centric and product-based mindsets to an inter-organizational supply chain orientation involving customers, suppliers, and other partners. They also have shown that SCQM across inter-organizational supply chains has received scant research attention, even though that perspective is sorely needed in delivering value to customers in often globally scattered supply chains [Robinson and Malhotra (2005)]. A case study of a firm that is a first-tier supplier in an offshoot of automotive supply chain is presented to better illustrate the SCQM themes and their treatment in industrial practice. Based on our research, the case study, and experience of working with firms in the domain of quality management and the ISO 9001 certification processes, we propose a Quality-SCM framework that can be used to place prior work in perspective, as well as identify three specific opportunities for future SCQM research [Robinson and Malhotra (2005)].

Foster (2008) has defined supply chain quality management (SCQM) to operationalize and understand the effect of increased emphasis on supply chain management on the practice of quality management. He has reviewed current research in quality management and has identified common themes found in the literature. Key quality management content variables identified were customer focus, quality practices, supplier relations, leadership, HR practices, business results, and safety. He has used these variables to propose areas for future research in the field of supply chain quality management [Foster (2008)].

Lin and et. al (2005) have identified through the use of empirical data collected from Taiwan and Hong Kong, the factors that influence supply chain quality management. The data was collected from practicing managers. Their findings for the two sets of data were consistent. The data showed that Quality Management (QM) practices are significantly correlated with the supplier participation strategyand this influences tangible business results, and customer satisfaction levels. The data also showed that QM practices are significantly correlated with the supplier selection strategy. The empirical results presented could be used to improve the management of supply chain networks in the economies studied [Lin and et. al (2005)].

Kannan and Tan (2005) empirically have examined the extent to which just in time, supply chain management, and quality management are correlated, and how they impact business performance. Their results demonstrated that at both strategic and operational levels, linkages exist between how just in time, total quality management, and supply chain management are viewed by organizations as part of their operations strategy. Results also indicated that a commitment to quality and an understanding of supply chain dynamics had the greatest effect on performance [Kannan and Tan (2005)].

Li and Lin (2006) empirically have examined the impact of environmental uncertainty, intra-organizational facilitators, and inter organizational relationships on information sharing and information quality in supply chain management. Based on the data collected from 196 organizations, multiple regression analyses were used to test the factor impacting information sharing and information quality respectively. It is found that both information sharing and information quality were

Influenced positively by trust in supply chain partners and shared vision between supply chain partners, but negatively by supplier uncertainty. Top management had a positive impact on information sharing but had no impact on information quality. The results also showed that information sharing and information quality were not impacted by customer uncertainty, technology uncertainty, commitment of supply chain partners, and IT enablers. Moreover, a discriminant analysis reveals that supplier uncertainty, shared vision between supply chain partners and commitment of supply chain partners are the three most important factors in discriminating between the organizations with high levels of information sharing and information quality and those with low levels of information sharing and information quality [Li and Lin (2006)].

Wever and et. al (2010) empirically have examined the relation between QMSs and GSs in pork meat supply chains. Transaction- Cost-Economic theory is used to develop propositions about the relation between three aspects of QMSs ownership, vertical scope and scale of adoption - and the use of different types of GSs in pork meat supply chains. To validate the propositions, seven cases are examined from four different countries. Their results showed that the different aspects of QMSs largely relate to specific GSs used in chains in the manner predicted by the propositions. This supports the view that alignment between QMSs and GSs is important for the efficient coordination of quality management in (pork meat) supply chains [Wever and et. al (2010)].

Sroufe and Curkovic (2008) have utilized case-based research to address the competing views of the ISO 9000:2000 standards in an attempt to see if a sample of firms in the automotive industry can be positioned within the Miles and Snow strategic typology. We compare different amounts of quality standard integration and quality assurance in the supply chain of firms with ISO 9000:2000

registration while positing several research propositions [Sroufe and Curkovic (2008)].

Tsai (2006) has attempted to simultaneously vary all of the variables to achieve the global optimum for the optimal variable selections of R&D and quality design. Genetic algorithm (GA) can treat all of the variables for the global search. In this study, fuzzy refinement with orthogonal arrays was effective in improving the performance of the GA, and also showed the benefits of a good chromosome structure on the behavior of GA. It is also proposed the postponement design with temporal concept, to select the effective variables for the cost reduction of R&D and quality management design. The experimental results showed that tempo postponement design will increase the flexibility and quick response for supply chain management. Hence, this approach can act as a useful guideline for researchers working on the optimization of the key variable selections for R&D and quality model design [Tsai (2006)].

Castillo-Villar, Smith and Simonton (2012) have presented a model for supply chain design that computes the COQ as a global performance measure for the entire supply chain. In addition their model has computed COQ in terms of internal operational decisions such as the error rate at inspection and fraction defective at manufacturing. The model can be used to design a logistic route that achieves a minimum total cost while maintaining an overall quality level and to evaluate the impact of investment in quality to increase overall profits. The behavior of the model is illustrated with numerical examples that show how the COQ function changes depending on various parameters [Castillo-Villar, Smith and Simonton (2012)].

Tse and Tan (2012) have argued that better visibility of risk in supply chain could minimize the threat of product harm. A supply chain product quality risk management framework, integrating both the incremental calculus and marginal analysis, was proposed. Results indicated that the proposed approach had the following benefits: (i) providing evaluation of the product quality risk in supply chain layers; (ii) allowance for firms to have a better 'visibility' of product quality risks in supply chain; and (iii) a traceable justification path for multi-sourcing decision [Tse and Tan (2012)].

3. Model Specification

We have introduced a regression model for considering the impact of supply chain management index on quality management.

We have used following index for formation of supply chain management index, we have used prior studies for formation the index:

X1: Delivery on time of Materials
X2: Delivery order of Customers
X3: Supply chain response time
X4: Production process flexibility
X5: Cost of supply chain management
X6: Warranty costs
X7: Labor Productivity
X8: Capital Productivity
X9: Displacement rates of net assets
X10: Total Factor Productivity
X11: ICT index of organization (Knowledge Management Index)
X12: Human Capital Index [1-14]

Then, we have formatted supply chain management index based on prior studies and Calibration method as following:

$$SCM_{it} = \sum_{i=1}^{12} \alpha_i X_{it} \qquad (1)$$

where t is index of time for a given firm. α_i is coefficient of X_{it} . α_i is extracted by Calibration Method.

For measuring Quality Management Index, we have used following factors:

Y1: Customer Satisfaction Index
Y2: International Standard Index (ISO and other indexes)
Y3: National Standard Index [1-14]

Then, we have formatted Quality management index as following:

$$QM_{it} = \sum_{i=1}^{3} \beta_i Y_{it} \qquad (2)$$

β_i Is extracted by Calibration Method. Then, we can introduce new model for considering the impact of Supply Chain management index on Quality management index.

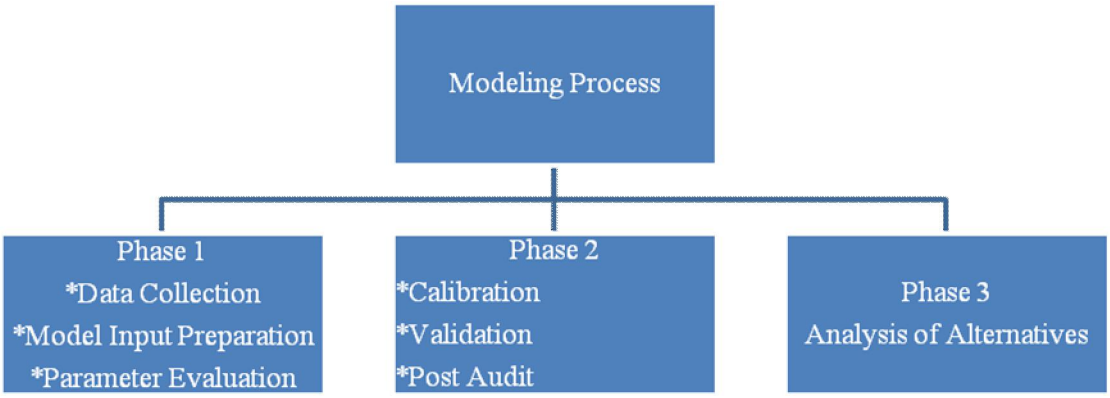
$$QM_{it} = \gamma + \vartheta SCM_{it} + \delta Z + \varepsilon_t \qquad (3)$$

Where Z is vector of control variables that effect on QM and ε_t is error term of regression. γ, ϑ and δ are parameters of the regression.

Calibration is procedures to determine class membership probabilities which assess the uncertainty of a given new observation belonging to each of the already established classes. Also, "calibration" is used in statistics with the usual general meaning of calibration.

For instance, calibration can be also used to refer to Bayesian inference about the value of a model's parameters, given data set, or more generally to any type of fitting of a statistical model.

The modeling process with calibration is as following figure:



3.1. Data Collection

We have used the data of 280 firms of Iranian firms in Tehran Stock Exchange.

4. Simulation and Results

We have simulated the equation (3) and estimated the model as following table:

Table 1. Simulation Results of the model (3)

Dependent Variable: QM				
Method: Least Squares				
Date: 12/06/12 Time: 11:44				
Sample: 1 200				
Included observations: 200				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.482090	0.029371	16.41367	0.0000
SCM	10.01609	0.014570	687.4683	0.0000
Z1	3.002202	0.014007	214.3430	0.0000
R-squared	0.999627	Mean dependent var		13.79568
Adjusted R-squared	0.999624	S.D. dependent var		15.25569
S.E. of regression	0.295971	Akaike info criterion		0.417775
Sum squared resid	17.25695	Schwarz criterion		0.467249
Log likelihood	-38.77746	Hannan-Quinn criter.		0.437796
F-statistic	264257.3	Durbin-Watson stat		1.957989
Prob(F-statistic)	0.000000			

The estimation results indicate:

1. Supply Chain Index has a significant Positive impact on Quality Management Index.
2. doing business index and environmental economic factor have a significant positive impact on Quality Management Index.
3. F-Statistic indicates that the regression is significant. Also, R-squared is 99% that means the model has suitable goodness of fit.
4. Durbin-Watson test indicates that there is no serial correlation between residuals series.
5. t-statistic criteria indicate that all parameter of the model are significance.

Figure 1 indicates simulated series of supply chain and quality management indexes and figure 2 indicates forecasted quality management index.

Figure 1. Simulated Series of Supply Chain and Quality Management Series

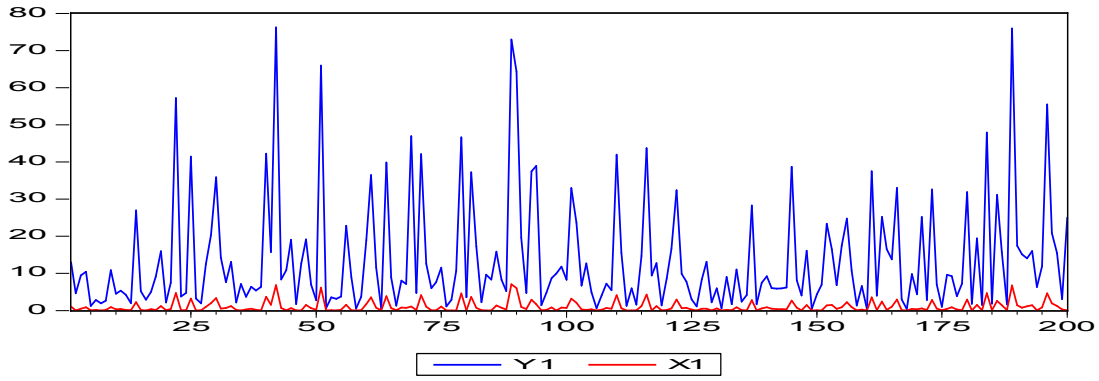
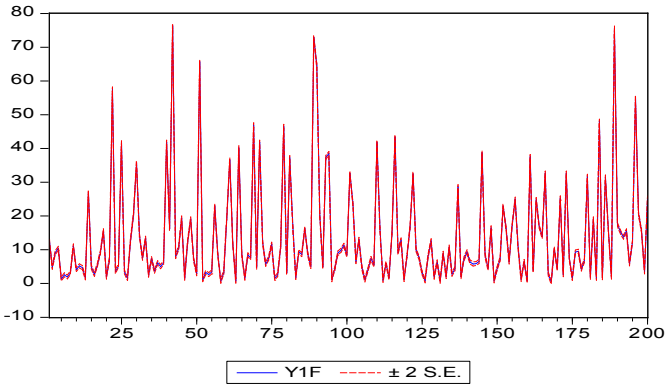


Figure 2. Forecasted Quality Management Index



Forecast: Y1F
Actual: Y1
Forecast sample: 1 200
Included observations: 200

Root Mean Squared Error	0.293743
Mean Absolute Error	0.257800
Mean Abs. Percent Error	6.970287
Theil Inequality Coefficient	0.007151
Bias Proportion	0.000000
Variance Proportion	0.000093
Covariance Proportion	0.999907

5. Conclusion

In recent years, there is more attention on supply chain and quality management. This subject introduced as supply chain quality management. Supply chain and quality management are two important factors in every firms or organization.

We have introduced a regression model for considering the impact of supply chain management index on quality management. This paper has introduced two indexes for measuring supply chain and quality management, also this paper has introduced a regression model for interaction between supply chain and quality management. A new approach in this paper is using Calibration and Simulation method for measuring and estimation the parameter of the model. The estimation results indicate: Supply Chain Index has a significant Positive impact on Quality Management Index.

Distinguishes this study from previous studies is introduce a new method for considering the impact of supply chain management on quality management with calibration and simulation approaches.

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