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Determining Underlying Characteristics of Supplier Evaluation Model: A Quantitative Empirical Research

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Abstract: Rapid changes in the business environment, driven by competitive pressures and business complexity, present challenges that organizations cannot address without the support of their suppliers. In the past decades, performance evaluation factors such as quality, delivery, and price have been widely used by organizations to measure their suppliers' performance. Traditional supplier performance dimensions now considered to be only single dimensional, and not guarantee long term success of an organization. Use of internationally recognized standards and guidelines are recommended to be feasible for supplier Quality Management System evaluation in the literature. However, their effectiveness as a supplier evaluation tool has not been fully explored. In this research, relationship between Organization Performance dimensions and QMS criteria using MBNQA dimensions are explored.

Keywords: Supplier Evaluation, MBNQA, QMS, Performance Evaluation

1. Introduction

In today's competitive environment, a company's performance does not depend upon its capabilities alone. It also depends on the value a company receives from its suppliers. As competition increases and markets became global, so did the challenges associated with getting a product and service to the right place at the right time at the lowest cost. Organizations began to realize that it is not enough to improve efficiencies within the processes, but their whole supply chain has to be made competitive. Thus, understanding and practicing of supply chain management (SCM) has become important for staying competitive in the global market and for improving profitability.

Purchasing firms can't afford to buy from suppliers that ship substandard products, miss delivery dates, or charge too much. Thus, buying firms become highly selective in their choice of suppliers. They expect suppliers to attain and maintain established standards of product quality, service, technical support, distribution and partnering. However, without careful monitoring of supplier performance, a firm is unable to accurately assess whether its current and/or future suppliers are meeting these needs of the firm.

Most empirical studies in literature suggest that cost, technical competency (providing quality), and delivery performance are the three most preferred criteria in supplier evaluation. Technical competency being the ability to produce high quality products to meet customer satisfaction; delivery performance being the ratio of late deliveries to total shipments sent, and cost being the costs that are incurred to prevent, detect and remove defects from products.

However, in recent years, those firms that choose to routinely evaluate their suppliers have been experiencing evaluation design and content issues. Indeed, organizations have expressed several concerns with the existing state of supplier evaluations: they argue that other factors are likely as important as cost, quality and delivery in the evaluation of suppliers, and thus must be considered. They suggested many existing supplier evaluation measures may fail to consider a myriad of other variables, mostly qualitative in nature, which may affect the value of a supplier relationship from a supplier partner perspective.

A good overall evaluation should cover many other aspects of business, such as cycle time efficiency, worker attitudes, management backgrounds, systems, as well as safety, commitment and planning. A second group of factors, including continuous improvement/innovation, interdepartmental communication, employee involvement and recognition, customer relationship and communication, strategic planning, and financial conditions, should be considered equally important -- more important than the remaining factors. Hence, using more structural approach to evaluate supplier performance such as the framework of award models should be considered.

Use of internationally recognized standard such as MBNQA is considered to be suitable for supplier quality management system evaluation. The fundamental purpose of the MBNQA criteria is to provide set of relative and competitive

standards in terms of overall measurement of the QMS. MBNQA provides a broad framework for implementing a quality program and establishes guidelines for monitoring and measuring quality progress. Because MBNQA criteria are much broader, we recommend using the modified version of the criteria for supplier QMS evaluation. Hence, this exploratory research seeks to investigate and determine the underlying characteristics of an effective supplier evaluation model. This research will capture the relationship between single dimensional supplier performance measurement criteria (quality, delivery, cost) and QMS evaluation criteria (using MBNQA dimensions), and it will explore if low, medium and high performing suppliers underline different pack of quality management practices. In other words, the results of this study will help purchasing firms to understand which quality management practices can improve quality, delivery and financial performance of the suppliers. In addition, buying organizations can use this information to focus their supplier development efforts on practices that might generate measurable benefits.

2. Method

The data-collection instrument is a questionnaire consisting of three sections. Section one measures demographic information about the supplier organizations in order to make inferences from the results. Section two measures supplier performance based on quality, delivery and cost using the questions prepared by the researcher. Section three generates scores for key dimensions of Malcolm Baldrige National Quality Award (MBNQA). These dimensions are: leadership, Information and Analysis, Strategic Planning, Human Resource Development and Management, Process Management, Business Results, Customer Focus and Customer Satisfaction.

For the purpose of this research, suppliers of an Original Equipment Manufacturer were chosen (a total of 170) to be surveyed. All responses were protected under confidentiality agreement, ensuring that the scores of the suppliers will not be shared with any other organization and will not have an effect on the status of the supplier at OEM.

A total of 144 suppliers responded, out of which 6 were missing significant data, which in result totals to 81% response rate. A summary report was promised to respondents, who wish to receive one. 83% of the respondents indicated that they would like to receive a copy. It is believed that one of the reasons for high response rate is this summary report. Another reason is believed to be the good and trusting relationship, more importantly partnership the local OEM has with its suppliers. High response rate provided evidence that suppliers were interested in any improvement suggestions they might receive from their customer, and they were convinced that the data they provided would not affect their supplier status in any ways.

61% of the industries were public and 39% were private. All of the public sector industries (84) were from the Industrial Machinery and Equipment (33), Rubber and Miscellaneous Plastics Products (30), Chemicals (8), and Fabricated Metal Products (13). On the other hand, private sector industries (54) were from the Industrial Machinery and Equipment (11), Rubber and Miscellaneous Plastics Products (10), Fabricated Metal Products (9), Printing and Publishing (6), Electronics & Other Electrical Equipment (4), and Other Manufacturing Industries (14)

The size of participating companies is determined based on number of employees working. Company size and industry type were measured as control variables. The mean of company size of all participating companies lie between 500-999 ranges. Majority of the participants have number of employees in 500-999 range (44), following organizations with number of employees in 250-499 range (39), >1000 (21), <100 (19), and 100-249 range (15).

3. Results

The data analysis section of this research involves identifying relationships between organizational performance dimensions and QMS criteria. This analysis is done through three approaches. The first approach uses regression analysis – Anova method to determine the relationship between organizational performance dimensions of quality, delivery, cost and QMS score. Second approach uses multiple regressions – partial correlation where contribution of an individual variable when the other variables are held constant (to eliminate the effect) is analyzed. With this method, each variable of organizational performance is correlated with QMS performance. Canonical correlation analysis will be used as third approach to identify relationships between the sets of dimensions for organizational performance and QMS performance. However, before beginning the analysis of the relationships between Organizational Performance dimensions and QMS criteria, the homogeneity of the sampling population and scale reliability are verified.

3.1 Homogeneity of Data

The purpose of determining homogeneity of the sampling population before starting the analysis is to ensure that no significant variances in organizational performance and QMS performance are contributed by demographic factors such as company size and industry type. A comparison of the means on the organizational performance dimensions and QMS

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performance criteria is conducted using a Chi Square test. A summary of results that demonstrates the significance of the effects of company size and industry type on organizational performance and QMS performance is presented in Table 1 below.

Table 1. Significance of Demographic Effects. Chi Square Test Significance Scores.

	Company Size	Industry Type
Organizational Performance		
Quality	0.566	0.893
Delivery	0.446	0.796
Cost	0.365	0.813
QMS Performance		
Leadership	0.404	0.541
Information and Analysis	0.765	0.666
Strategic Planning	0.685	0.457
HR	0.964	0.460
Process Management	0.419	0.352
Customer Satisfaction	0.398	0.431

As seen on Table 1, company size and industry type do not provide any significant amount of variation of organizational performance. Organizational performance of the companies in the study is homogeneous as far as the company size and industry types are concerned. In addition, company size and industry type also don't provide any significant variances to the QMS score in the study.

3.2 Scale Reliability

Organizational performance scales are found to be reliable with Cronbach's alpha values above the required minimum, specified by Nunnally (1978) as 0.7 and as 0.5. Quality scores 0.848, delivery scores 0.762, cost scores 0.732, total score 0.778. The TQM scales are found some what reliable, with Cronbach's Alpha scores ranging from 0.521 for the Customer Focus and Satisfaction score, to .837 for the Human Resource score. The remaining scales have scores of: Leadership Alpha = 0.681, Information Analysis Alpha = 0.603, Strategic Planning Alpha = 0.720, Process Alpha = 0.673, and Total Score Alpha = 0.778. Customer Focus and Satisfaction had the lowest alpha score of 0.521, followed by Information Analysis alpha of 0.603, Process Management alpha of 0.673 and Leadership alpha of 0.681, all below the desired limit of 0.70.

3.3 Effects of Organizational Performance Level on QMS Performance

Using regression analysis, Anova method the relationship of each individual organizational performance dimension to QMS score is obtained. To identify the relationship that exist between the dependent variables and independent variables, and also among the independent variables the correlation matrix is used. (Table 2) This matrix is sized in accordance with the number of variables being investigated. A correlation coefficient for each combination of two variables appears at the intersection of every row and column of the correlation matrix. Any coefficient between two categories greater than 0.8 can be considered a strong relationship. (Hanke and Reitsch, 2001; Anderson, Sweeney and Williams, 2004) For example, Quality and total QMS score have a strong relationship since their coefficient is 0.953. Similarly, the coefficient of Delivery and QMS score is also about 0.822, which indicates both of these categories are highly correlated to each other. On the other hand, the relationship between QMS score and COST performance is found to be weaker with coefficient value of 0.547.

If any of the two independent variables in the multiple regression are too highly correlated, this condition is called multicollinearity. According to Hanke and Reitsch (2001), if the correlation between two independent variables are below the lower of the two correlations between independent and dependent variable multicollinearity is not an issue. In this research, quality and delivery has a high correlation coefficient of 0.80, but is below the Quality-QMS coefficient of 0.95 and Delivery-QMS coefficient of 0.82. Thus, multicollinearity is not an issue. The relationships are presented in Table 2.

Table 2. Correlations Matrix

	Quality	Delivery	Cost	QMS
Quality	1	0.803	0.671	0.953
Delivery	0.803	1	0.702	0.822
Cost	0.671	0.702	1	0.547
QMS	0.953	0.822	0.547	1

Second method used to determine the relationship between organizational performance dimensions and QMS score is called partial correlation where the relationship between each individual organizational performance dimension and QMS score is analyzed when the other two organizational performance dimensions are held constant. The technique is commonly used in "causal" modeling of small models (3 - 5 variables). The controlled correlation results are then compared with the original correlation and if there is no difference, the inference is that the control variables have no effect. If the partial correlation approaches 0, the inference is that the original correlation is spurious -- there is no direct causal link between the two original variables because the control variables are either (1) common anteceding causes, or (2) intervening variables.

In most cases a partial correlation of the general form will turn out smaller than the original correlation. In those cases, where it turns out larger, the third variable is typically spoken of as a suppressor variable on the assumption that it is suppressing the larger correlation that would appear between two variables if third variable was held constant. The relationships are presented in Table 3.

Table 3. Partial Correlation Results

Control Variables	Correlations
Quality- Cost	QMS - Delivery => r = 0.356
Delivery- Cost	QMS - Quality => r = 0.951
Quality – Delivery	QMS - Cost => r = 0.119

The partial correlation analysis results show:

1) With the effects of quality and cost removed the correlation between delivery and QMS score collapses down to a low value of 0.356. The practical inference is that if we were to administer the questionnaire to a sample of subjects who were homogeneous with respect to quality and cost, the correlation between their scores on the delivery and QMS sub-scales would prove fairly scant, on the order of 0.356.

2) The control variables delivery and cost have no effect on the correlation of QMS and quality, because compared with the original correlation there is no difference.

3) With the effects of quality and delivery removed the correlation between cost and QMS score collapses down to a low value of 0.119. In other words, when the effects of quality and delivery were held constant, the correlation between delivery and QMS would go lower, on the order of 0.119.

The third method of analysis performed is canonical correlation analysis. In this method all of the relationships between two sets of variables are analyzed.

In canonical correlation analysis, relationships are evaluated that take into consideration not only the effects of the independent variables on the dependent variables, but any relationships that may exist within the either the independent or dependent group of variables. This process is conducted simultaneously, unlike in regression analysis where only a single dependent variable is considered at a time.

The following forms of relationship are considered:

- Direct effects of one or more independent variables on one or more dependent variables.
- The effect of a relationship between two or more independent variables on one or more dependent variables.

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Using canonical correlation analysis, three pairs of canonical variables are obtained from the organizational performance and QMS variables. Each pair of canonical variables forms a relationship, which results in three relationships. The canonical variables and the relationships are presented in Table 4.

Table 4. Relationship between Organizational Performance Levels and QMS Dimensions

Canonical Relationships	Canonical Variable	Correlation between Set 1 & Set 2	Prop. Of variation in set explained	Sum of S2 coefficient
CV1	S1=0.865DELIVERY	0.751 (0.000)	0.245	
	S2=0.618STRA+0.532 PROC+ 0.472CUST + 0.838LEAD		0.215	1.128
CV2	S1=0.821 QUAL +0.802COST	0.854 (0.005)	0.159	0.648
	S2=0.618STRA+0.532 PROC+ 0.472CUST + 0.838LEAD		0.184	
CV3	S1=0.653 QUALITY – 0.621 COST	0.739 (0.122)	0.248	-0.089
	S2=3.865 STRAT – 3.112 HR		0.127	

Two of the three relationships derived are highly significant. CV1 has a correlation factor of 0.751, with a significance of 0.000 and CV2 has a correlation factor of 0.854, with a significance of 0.005. CV3 can be also considered in this analysis although the significance of the correlation is lower at 0.122, but it is still strong enough to deserve attention in this research.

These three relationships are best analyzed in two parts: CV1 can be analyzed independently while the effects of CV2 and CV3 can be combined. The first relationship, CV1, indicates that an increase in DELIVERY level will increase STRAT, PROC, CUST and LEAD dimensions of QMS.

CV2 and CV3 are interesting relationships as they both involve the effect of altering QUALITY and COST. CV2 measures a combined relationship, where QUALITY and COST are emphasized simultaneously, whereas CV3 shows the difference between QUALITY and COST is maximized. CV2 indicates that if there is a combined increase in QUALITY and COST, LEAD and CUST scores are improved while INFO and PROC scores are decreased. According to CV3, on the other hand, if QUALITY is emphasized, and COST is minimized, STRAT scores are improved at the expense of HR scores.

From the sum of the coefficients of S2, it can be concluded that the most beneficial overall effect on QMS performance as measured by the total score, is by increasing both COST and QUALITY as indicated in CV2 and/or increase in DELIVERY. CV3- S2 can be considered negligible.

4. Conclusion

The results of this research provide interesting ideas for organizations. The use of canonical correlation analysis identifies several relationships that should help organizations in its evaluation of supplier performance. The results provide a clear understanding of major characteristics of supplier evaluation model. It helps to clarify much of the confusion surrounding the relationship between single dimensional supplier evaluation tools (quality, delivery, cost) and QMS evaluation tools (using MBNQA criteria). The results support the hypothesis that specific QMS dimensions have a different impact on the organizational performance levels: the relationships between organizational performance levels and QMS dimensions do exist and are complex. In other words, organizational performance dimensions seem to provide a facilitating function for some dimensions of QMS while deterring for others.

Managers and employees working in companies that have dealings with organizations that are tier one suppliers have to be aware that the differences between QMS levels cause significant differences in organizational performance level in terms

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of quality and delivery. By analyzing which criteria contribute most to the performance level some interesting similarities or effects can, however, be found. The canonical correlation results indicate that the combined Quality and Cost score can be best improved by increasing leadership and customer satisfaction criteria of the QMS. The first canonical relationship, CV1, shows that Delivery performance is to be increased to improve the QMS score. The Delivery performance has high significant coefficient in the linear regression equation. Organizations, therefore, should concentrate on increasing Delivery performance to increase Customer Satisfaction. In addition, Delivery performance is best improved with proper Leadership, accurate Strategic Planning and improved Process Management. Process Management construct in this research included the use of statistical techniques, process performance monitoring, cycle time reduction, and continuous improvement in terms of process output. Process management techniques can remove bottlenecks, reduce lead times, increase productivity, and thus improve delivery performance. However, the results suggest the effect of Process Management on Quality and Cost performance combined is opposite. When emphasis is put on lead time reduction, balanced and productive processes, Quality and Cost combined start to suffer, thus have a lower score.

Improved Information and Analysis criteria have similar effect on Cost, Quality and Delivery performance as Process Management criteria had. Information and Analysis criteria include how well the use of data and information managed by the organization, and how the data is collected and maintained.

Of the six QMS criteria studied Leadership and Customer focus were the only two criteria that demonstrated positive effect on all three organizational performance criteria: Delivery performance and Quality and Cost combined performance. Leadership in this study included setting clear strategic directions, clear and visible values, creating a work environment, where well-being of employees are important and employees have clear goals and are well informed of what is expected of them. The results showed Delivery performance as well as Quality and Cost performance combined is improved with improved Leadership. These results suggest people, how they are treated and communicated to makes a difference in overall performance.

Customer Focus and Satisfaction criteria included evaluation of systems for customer learning and for building and maintaining customer relationships. The customer satisfaction and retention, market share levels and trends are also examined under this criterion. The results suggest improved customer focus and satisfaction lead to improved Delivery performance and improved Quality, Cost combined performance.

This research contributes to deeper understanding of the business value and the strategic role of the elements of the model. It helps with the allocation of resources to those categories such as leadership, customer focus and satisfaction, process management, strategic planning that have the most significant effect on organizational performance. This research shows that underlying the systems view of organizational improvement is the nation that employees work in an organizational system. Such a system is much broader than work processes; it includes management of processes and people, and structural arrangements under the vision of leadership created to guide the organization toward its goals.

5. References

Anderson, David, Dennis Sweeney and Thomas Williams. (2004). *Statistics for Business and Economics*. Chicago: South-Western College Publications.

Flynn, B., Schroeder, R. G., and Sakakibara, S (1995). The Impact of Quality Management Practices on Performance and Competitive Advantage, *Decision Sciences* (26:5), 1995; pp. 659-692

Garson, G. D. (2014). *Partial Correlation*. Asheboro, NC: Statistical Associates Publishers.

Hanke, J. E., and Reitsch, A. G. (2001). *Understanding Business Statistics*. Irwin: Richard D. Inc.

Holmlund, M., and Kock, S. (1996). Buyer Dominated Relationships in a Supply Chain-A Case Study of Four Small-Sized Suppliers. *International Small Business Journal*, Vol. 15. Pages: 26-40. doi: 10.1177/0266242696151002.

Porter, L. J., and Tanner, S. J. (2004). *Assessing Business Excellence: A guide to business excellence and self-assessment* (2nd Edition), Taylor Francis Publications.

Nunnally, J.C., (1978). *The Psychometric Theory*. NewYork: McGraw-Hill Series in Psychology.

Park, S., Hartley, J. L., and Wilson, D. (2001). Quality management practices and their relationship to buyer's supplier ratings: a study in the Korean automotive industry. *Journal of Operations Management*. Vol. 19, Issue 6.