Spring 2007

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

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DETERMINING UNDERLYING CHARACTERISTICS OF SUPPLIER EVALUATION MODEL: A QUANTITATIVE EMPIRICAL RESEARCH

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A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirement for the Degree of

DOCTOR OF PHILOSOPHY

ENGINEERING MANAGEMENT

OLD DOMINION UNIVERSITY
May 2007

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ABSTRACT

DETERMINING UNDERLYING CHARACTERISTICS OF SUPPLIER EVALUATION MODEL: A QUANTITATIVE EMPIRICAL RESEARCH

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Old Dominion University, 2007
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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 such as ISO 9000, MBNQA 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 empirically tested. In this dissertation, relationships between Organization Performance dimensions and QMS criteria using MBNQA dimensions are explored.

Organizational Performance questionnaire that is developed by the researcher is used to determine the Performance Level of the supplier organizations. QMS performance of the supplier organizations is measured using a questionnaire developed at the University of Missouri-Rolla by Wu (1996). Suppliers of an OEM company in Virginia are surveyed. The regression analysis and canonical correlation analysis results of this dissertation show that there are relationships among the QMS dimensions using MBNQA criteria and Organizational Performance dimensions. The relationships are complex and often counteractive. Relationship models between QMS criteria and organizational Performance Dimensions are developed for the organizations participated in the study and finally, conclusions are drawn and recommendations made for future research.

This dissertation is dedicated to my parents
Dr. Semra Ozgun and Dr. Ibrahim Ozgun.
They have been endless source of inspiration for me.

ACKNOWLEDGMENTS

There are many people who have contributed to the successful completion of this dissertation. My major advisor Dr. Andres Sousa-Poza deserves special recognition and thanks for his patience, insight, and guidance. I extend my thanks to my committee members Dr. Raphael Landaeta and Dr. Shannon Bowling for their review, critical evaluation and advice.

I would like to thank the Management at Stihl Inc. for providing financial support during my education. Mr. Peter Mueller, Executive VP of Operations at Stihl Inc. deserves special recognition. He has been more than a boss for me. He showed me how a mentor and a true leader would be. It is no exaggeration to say that I would never have completed this program, nor would I be where I am today without his support.

I thank God for giving me the strength and the intelligence to finish this work and giving me the best parents one can hope for. I thank my parents Dr. Semra Ozgun and Dr. Ibrahim Ozgun for loving me and supporting me unconditionally. Thank you for your understanding and encouragement over many years of my academic undertakings. Even though it took time away from you, you always let me know that you supported me in what I was doing. I am proud to be your daughter.

Special thanks to my husband, Mutlu Ocak, for being there from the beginning. You were beside me through all of the years of academic pursuit. Thank you for believing in me when I doubted myself, for being my best friend, my soul mate and most critical editor. I am proud of what we have accomplished together.

Finally, everything was for you, my beautiful daughter Selin. After you came into my life, everything has changed. You gave me the purpose I needed to finish this work. You made me a different person. I want you to understand the importance of education, and know that you can be whatever you want to be. Believe in yourself, and I will be always there to support you when you need me.

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1. INTRODUCTION

1.1 Background

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 in the 1990s intensified 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 an organization, but their whole supply chain has to be made competitive. The understanding and practicing of supply chain management (SCM) has become an essential prerequisite for staying competitive in the global race and for enhancing profitably.

Council of Logistics Management (CLM) defines Supply Chain Management as the systemic, strategic coordination of the traditional business functions and tactics across these businesses functions within a particular organization and across businesses within the supply chain for the purposes of improving the long-term performance of the individual organizations and the supply chain as a whole. Supply Chain Management has been defined to explicitly recognize the strategic nature of coordination between trading partners and to explain the dual purpose of Supply Chain Management: to improve the performance of an individual organization, and to improve the performance of the whole supply chain.

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. 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

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Style conforms to the *Engineering Management Journal* Model.

partnering. However, without careful monitoring of supplier performance, a firm is unable to accurately access whether its current and/or future suppliers are meeting these needs of the firm.

Supplier performance measurement schemes are well established in the theory and practice of industrial purchasing. Under influence of the Japanese philosophies of Total Quality Management (TQM) and Just-In-Time (JIT) management, there is emphasis on assessment of supplier performance in terms of quality, on-time delivery, and price. These factors are also supported by literature as the most widely accepted tools for supplier selection and evaluation. An empirical study performed by Kannan and Tan (2002) concluded that cost, quality, and delivery performance were the three most preferred criteria in supplier evaluation. Similar results were also found on an article by Weber, Current and Benton (2002). Based on the review of 74 articles on supplier evaluation, they concluded that quality was the most commonly used factor followed by logistics performance and price in supplier evaluation. Results of another survey conducted by Simpson, Siguaw and White (2002) confirmed that the evaluation of supply chain functions is most effective when divided into three areas: technical competency, delivery performance, and competitive price. The authors defined technical competency as ability to produce high quality products to meet customer satisfaction; delivery performance as ratio of late deliveries to total shipments sent, and competitive price as percentage of price reduction compared to previous years.

In recent years, those firms that choose to routinely evaluate their suppliers have been experiencing evaluation design and content issues. Indeed, prior researchers have expressed several concerns with the existing state of supplier evaluations: they argue that other factors are likely to be as important as price, quality and delivery in the evaluation of suppliers. For example, according to Ellram (2001) it is important to note that strategic evaluation of suppliers leading to a long-term success requires consideration of supplier capabilities and practices. He suggested that 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. In addition,

researchers argue that broader array of objective data should be used to measure the supplier's effectiveness and progress toward achieving continuous improvement so that buying firms are not suddenly faced with technological obsolescence.

According to Park, Hardley and Wilson (2001) factors such as quality, delivery, and price are considered to be only single dimensional and do not guarantee long term success of an organization. While these factors are important in evaluating supplier performance, they only deal with part of the supplier evaluation process. For example, a supplier may be achieving high level of performance by utilizing large amounts of resources and thus be an inefficient performer. From a strategic point of view, firms are more inclined to develop long-term relationships with suppliers that are both high performers and highly efficient. This is because such suppliers are more likely to have the infrastructure and organizational capabilities in place to effectively meet the changing demands of the buying firm in the long run. Thus, in order to comprehensively evaluate the performance of suppliers, it is necessary to consider the type and amount of input resources (i.e., practices relating to the technical, managerial, and operational capabilities) utilized in generating performance outcomes. Therefore, a measure of efficiency in addition to performance solely based on outputs (e.g., cost, quality, and delivery performance) is warranted.

Authors such as Doney and Cannon (1997), Wilson (1994) have also expressed several major concerns with the existing state of supplier evaluation models based on measures such as product quality, price and delivery. 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.

Simpson, Siguaw, and White (2002) agree that supplier evaluations should go well beyond the three dimensions noted by many researchers (quality, price, delivery). They indicate 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, they recommend using more structural approach to evaluate supplier performance: such as the framework of award models.

Use of internationally recognized standards and guidelines such as ISO 9000, MBNQA are recommended to be feasible for supplier quality management system evaluation by other authors, as well. (Curkovic and Handfield, 1996; Watson, 2002). From the outset, it must be recognized that each one of the two systems is based on a different set of objectives, because the two programs are designed for different purposes. ISO 9000 criteria represent model guidelines which promote the broad participation and qualification as many companies as possible. Therefore, this program can be viewed as a set of absolute standards to ensure conformance quality. As a result, it provides a common basis for an independent and transferable supplier qualification system. On the other hand, the basic purpose of the MBNQA criteria is to select a winner of the award and to enhance competitiveness. The criteria are set of relative and competitive standards in terms of overall measurement of the QMS, which attempt to rank order the applicants. MBNQA application provides a broad framework for implementing a quality program and establishes benchmarks suitable for monitoring and measuring quality progress (Curkovic and Handfield, 1996). Because the MBNQA criteria are much broader, it is recommended to use the modified versions of the criteria for supplier QMS evaluation. However, because of the fact that there is little to no evidence exist regarding the impact of MBNQA criteria and ISO 9000 guidelines on supplier performance, their application as supplier evaluation tool is not as common and not yet empirically confirmed.

The criteria to be used for supplier evaluation must be chosen carefully given that a supplier can be instrumental in providing value to a firm and can serve as a source of competitive advantage. For example, according to Choi anc Eboch (1998), due to fact that quality of an organization's products and services is directly related to the quality of their suppliers' products and services, suppliers provide one of the most critical links to an organization's profit, market share, and survival. A supplier that creates a strong brand image for its products through high quality standards and creative advertising can

dramatically increase the sales of the reseller, or a supplier utilizing electronic data interchange can dramatically reduce the product cost for the buying firm. (Simpson, Siquaw and White 2002). It is therefore believed that choosing the right supplier is perhaps the most important responsibility of the purchasing function, and supplier evaluation is one of the most important activities during the supplier selection process. An effective supplier evaluation system identifies the suppliers best equipped to meet the customer's expected level of quality with best quality management practices, and checks them periodically and systematically. (Van der Wiele and Williams, 2000) However, before researchers can normatively prescribe how buying firms should be assessing suppliers, in terms of dimensions to be included, and their effects, the current state of evaluative procedures must be understood. One purpose of this research is to review the procedures companies can formally use to evaluate their suppliers and identify which factors are most important in supplier evaluation. The latter analysis will serve the foundation of this research. It will determine whether firms can and should move beyond examining only price, quality, and delivery factors, and which factors should be used for an effective supplier evaluation model.

2. REVIEW OF LITERATURE

The literature review for this dissertation was conducted from three bodies of knowledge. In the first body, first Supply Chain Management will be defined, followed by overviews of the four most popular quality system guidelines and awards such as Six Sigma, Deming Award, MBNQA criteria and ISO 9000 Quality Standards.

In the second body, Organizational Performance Measurement in terms of quality, delivery and cost performance, is discussed in detail.

Since the early 1980s when quality emerged as an important facet of competition, researchers have been trying to empirically test the relationship between QMS criteria and organizational performance dimensions, and despite an increasing number of empirical studies, it has not been confirmed yet. The third body will cover the results of the literature review on this relationship.

2.1 Supply Chain Management

In the past three decades, the relationship between customers, manufacturers and suppliers has undergone numerous paradigmatic changes. Modern manufacturing paradigms such as the just-in-time (JIT) philosophy, total quality management (TQM) and agile manufacturing, advocate the elimination of non-value adding activities in procurement, production and distribution. The progressive approach espoused by these paradigms is to view individual actions as part of an integrated series of business functions that span across the entire supply chain.

Supply Chain Management is the term used to describe the management of materials and information across the entire supply chain, from suppliers to final assemblers to distributors, and to the customers. (Kannan and Tan, 2002) There is no universally accepted definition of a supply chain. Different resources provide different definitions that are widely used. Educational Society for Resource Management, has one of the better ones:

The processes from the initial raw materials to the ultimate consumption of the finished product are linking across supplier-user companies. The functions inside and outside a company that enable the value chain to make products and provide services to the customer.

Figure 1 below illustrates basic supply chain with three entries – a producer with one supplier and one customer. These "entities" that perform the processes can be business or governmental organizations or (at least in theory) individuals. They can also be departments or functional areas or individuals within a larger organization; there are internal as well as external supply chains. For the most part the model applies to corporations.

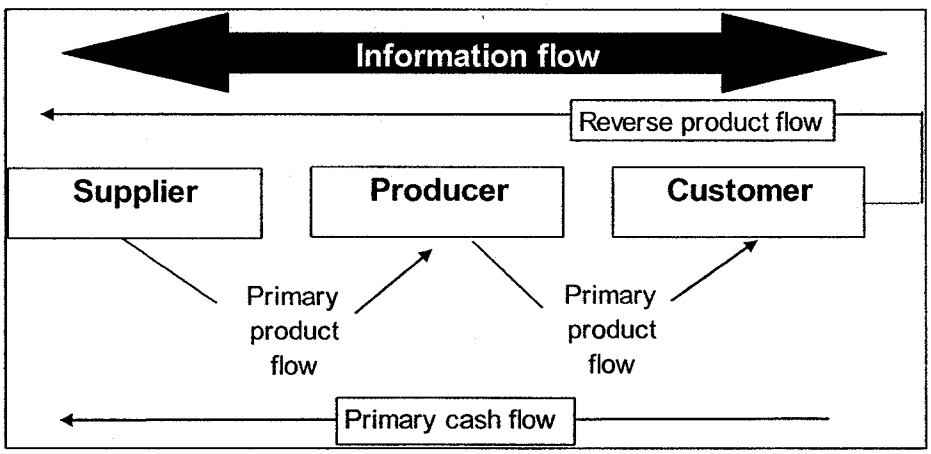

Figure 1 Basic Supply Chain Model.

Most work on supply chains, both theoretical and applied, involves a manufacturing firm in the middle with a supplier of materials or components on the "upstream" side and a customer on the "downstream" side. Technically, a supply chain needs only those three entities to exist. The chain model in Figure 1 is made up of the following organizations:

- A supplier that provides materials, energy and services, or components for use in producing a product or service.

- A producer that receives services, materials, supplies, energy, and components to use in creating finished products.

- A retailer that receives shipments of finished products to deliver to its customers.

Four basic flows connect these entities together:

- The flow if physical materials and services from suppliers through the intermediate entities that transform them into consumable items for distribution to the final customer

- The flow of cash from the customer back "upstream" toward raw material supplier

- The flow if information back and forth along the chain (also back and forth within the entities and between the chain and external entities)

- The reverse flow of products returned for repairs, recycling, or disposal (This is called the reverse supply chain, and it is handled by reverse logistics, which involve different arrangements from the forward logistics that carried materials and products in the other direction)

Supply Chain Management (SCM) is the combination of art and science that goes into improving the way a company finds the raw components it needs to make a product or service and deliver it to customers. The following are five basic components of SCM:

1. **Plan** – This is the strategic portion of SCM. You need a strategy for managing all the resources that go toward meeting customer demand for your product or service. A big piece of planning is developing a set of metrics to monitor the supply chain so that it is efficient, costs less and delivers high quality and value to customers.

2. **Source** – Choose the suppliers that will deliver the goods and services you need to create your product. Develop a set of pricing, delivery and payment processes with suppliers and create metrics for monitoring and improving the relationships. And put together processes for managing the inventory of goods and services you receive from suppliers, including receiving shipments, verifying them, transferring them to your manufacturing facilities and authorizing supplier payments.

3. **Make** – This is the manufacturing step. Schedule the activities necessary for production, testing, packaging and preparation for delivery. As the most metric-intensive portion of the supply chain, measure quality levels, production output and worker productivity.

4. **Deliver** – This is the part that many insiders refer to as logistics. Coordinate the receipt of orders from customers, develop a network of warehouses, pick carriers to get products to customers and set up an invoicing system to receive payments.

5. **Return** – The problem part of the supply chain. Create a network for receiving defective and excess products back from customers and supporting customers who have problems with delivered products.

In total dollars, external suppliers provide a significant portion of a manufacturer's product. For U.S. firms, 80% or more of the final price of a product can be the cost of purchased goods. Supply Chain Management, therefore, is considered critical to a company's competitiveness and future success.

One of thee goals of supply chain management is to reduce uncertainty and risks in the supply chain, thereby positively affecting inventory levels, cycle time, processes, and ultimately, end-customer service levels. Effective supply chain administration requires a proactive management style focused on long-term continuous improvement of the supply chain. An effective Supplier Chain Management is likely to facilitate the building of strategic partnerships. Developing such partnerships with suppliers is vital to a successful supply chain. (Kannan and Tan, 2002) It allows companies to integrate with their critical

suppliers to streamline order management, replenishment and fulfillment; inventory management; and engineering change management. Many companies have been moving toward strategic sourcing, a collection of activities preceding the signing of a contract. Strategic sourcing includes analyzing expenses, identifying potential suppliers, requesting quotations and negotiating contracts, and monitoring and improving suppliers. Companies have also started to limit the number of suppliers they do business with by implementing vendor review programs that identify suppliers with operational excellence. A close buyer-supplier relationship is important because suppliers in such a relationship are easier to work with and provide better service.

Supply Chain Management has generated much interest because of the realization that actions taken by one member of the chain can influence the profitability of all others in the chain. This realization has led to supplier quality management that is the performance of suppliers and how it is measured. In a recent survey of more than 200 companies, Deloitte Consulting found that while 91% of manufacturers rank SCM as either critical or very important to their company's success, only 2% rank their supply chains as world class.

The concept of Supply Chain Management has also received increasing attention from academicians, consultants, and business managers. Organizations have begun to recognize that SCM is the key to building sustainable competitive edge for their products and/or services in an increasingly crowded marketplace. The concept of Supply Chain Management has been considered from different points of view in different bodies of literature, such as purchasing and supply management, logistics and transportation, operations management, marketing, organizational theory, and management information systems.

However, despite the increased attention paid to Supply Chain Management, the literature has not been able to offer much by way of guidance to help the practice of Supply Chain Management. This has been attributed to the interdisciplinary origin of Supply Chain Management, the conceptual confusion, and the evolutionary nature of the concept. There is no generally accepted definition of Supply Chain Management in the literature. The

concept of Supply Chain Management has been involved from two separate paths: purchasing and supply management, and transportation and logistics management. According to purchasing and supply management perspective, Supply Chain Management is synonymous with the integration of supply base that evolved from the traditional purchasing and materials functions. In the perspective of transportation and logistics management, Supply Chain Management is synonymous with integrated logistics systems, and hence focuses on inventory reduction both within and across organizations in the supply chain. Eventually, these two perspectives evolved into an integrated Supply Chain Management that integrates all the activities along the whole supply chain.

The evolutionary nature and the complexity of Supply Chain Management are also reflected in the literature. Much of the current theoretical/empirical research in Supply Chain Management focuses on only the upstream or downstream side of the supply chain, or certain aspects/perspectives of Supply Chain Management. Topics such as supplier selection, supplier involvement, and manufacturing performance, the influence of supplier alliances on the organization, success factors in strategic supplier alliances and the antecedence and consequences of buyer–supplier relationship have been researched on the supplier side. It must be noted that as more organizations adopt an outsourcing strategy, the importance of supplier evaluation process increases for the engineering management profession, because of the following reasons:

- It can be only determined what to improve at the supplier, if performance is measured.
- Hidden waste, quality, and cost problems in the supply chain can be only uncovered if performance is measured.
- Problems can be prevented and supplier performance improvement activities can be implemented.
- Business decisions will be based on factual data that impact the entire supply chain.

Determining what performance an organization wants from its supply chain need a supplier strategy that relates to organizational goals and objectives. Many organizations are pursuing continuous improvement programs and methodologies such as six sigma, lean enterprise, lean sigma, operational excellence and TQM. Organizations trying to get to the next level of excellence would like to have their suppliers align with their own organizational direction. (Kannan and Tan, 2002) A company pursuing lean and just in time deliveries, would need at least key suppliers to be on a lean journey as well, because the lack of synchronization can adversely impact cost, quality and delivery. A company committed to six sigma and has developed fact based culture would require a similar approach to performance improvement from its key suppliers.

The challenge on the argument above is – how to collect any of the information for a large portion of the supply base using available resources. The information is difficult to deploy, requires knowledge of what to measure and is resource intensive for both customer and supplier. Most challengingly it is hard to construct sound performance metrics to measure desired performance. To this extent, some of the important quality system guidelines and quality award criteria are reviewed and compared in terms of similarities and differences, in this section.

2.2 Six Sigma

Six Sigma is a rigorous, focused and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, six sigma aims for virtually error free business performance. Six Sigma methods integrate principles of business, statistics and engineering to achieve significant results. Six Sigma tools are used to improve the processes and products of a company. They are applicable across every disciple, including Production, Sales, Marketing, Design, and Service. (Pande, Neuman and Cavanagh, 2002)

The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of Six Sigma improvement projects. This is accomplished

through the use of two Six Sigma sub-methodologies: DMAIC and DMADV. The Six Sigma DMAIC process (define, measure, analyze, improve, control) is an improvement system for existing processes falling below specification and looking for incremental improvement. The Six Sigma DMADV process (define, measure, analyze, design, verify) is an improvement system used to develop new processes or products at Six Sigma quality levels. It can also be employed if a current process requires more than just incremental improvement. (Pyzdek, 2003)

Once an organization decides to implement a Six Sigma program, it must impart the challenge to every employee. This includes not only people close to production, where indexes and measurements are relatively easy to implement on physical processes, but also administrative and service providers. Through executive directives, the organization establishes its Six Sigma challenge, vision, customer satisfaction and new measurement indexes. It establishes a common goal for all employees in the organization: reduce variability in everything they do.

A Six Sigma program also requires a review, as well as an audit, to make sure everything progresses as planned. What makes a Six Sigma program successful is a solid infrastructure, and a proven methodology that standardizes the right tools and techniques, and provides the working team with a step-wise progression to apply those tools.

Six Sigma philosophy deals with the application of the scientific method to the design and operation of quality management systems and business processes which enable employees to deliver the greatest value to customers and owners. (Pyzdek, 2003) The Six Sigma approach to quality management includes a Six Step process designed to achieve Six Sigma quality.

Step 1: Identify your product and services.

Step 2: Identify your customers and their needs.

Step 3: Identify what you need to provide your product and services and those who supply those needs.

Step 4: Describe your process as it is today.

Step 5: Eliminate effort that does not contribute to the end products and services and eliminate opportunities for error.

Step 6: Repeat these steps continuously – constantly strive to improve the processes so that the output is of higher quality.

Six Sigma way of doing business introduced six critical ingredients needed to achieve Six Sigma capability within an organization. (Pande, Neuman, Cavanagh, 2002) These are:

1. **Genuine Focus on the Customer**: Although companies have long proclaimed that "The Customer is Number One" or "Always Right", few businesses have actually succeeded in improving their understanding of their customers' processes and requirements. Customer focus is the top priority in Six Sigma. Performance measurement begins and ends with the Voice of Customer. "Defects" are failures to meet customer requirements.

2. **Data and Fact Driven Management:** Six Sigma teams clarify which measures are keys to actual business performance; they collect and analyze data to understand key variables and process drivers.

3. **Process Focus, Management and Improvement**: Six Sigma focuses on the process as the key means to meeting customer requirements. One of the most important impacts of Six Sigma has been to convince leading managers that mastering and improving processes is an essential step toward building competitive advantage by delivering real value to customers.

4. **Proactive Management:** In the world of business, proactive means making a habit of setting and then tracking goals; establishing clear priorities; challenging the way things are done instead of blindly defending the old ways. Constantly firefighting is the sign of an organization losing control. Six Sigma provides the tools and practices to replace reactive with proactive management.

5. **Boundaryless Collaboration:** "Boundaryless" refers to the job of smashing the barriers that block the flow of ideas and action up and down and across the organization. Six Sigma requires increased collaboration as people learn their roles in the big process picture and their relationship to external customers. By putting the customer at the center of the business focus, Six Sigma demands an attitude of using processes to benefit everyone.

6. **Drive for Perfection, Tolerate Failure:** Six Sigma places great emphasis on driving for perfection and making sustainable results happen within a useful business time frame. Six Sigma teams often find themselves trying to balance different risks. The biggest risk teams can take is to be afraid to try new methods.

2.3 Deming Prize

This award is named in honor of Dr. Deming, who is recognized as one of the fathers of the worldwide quality movement. This award was established to ensure good results are achieved through successful implementation of company wide quality control activities. Its purpose is to award companies that continually apply Company-Wide Quality Control (CWQC) based on statistical quality control and are likely to continue doing so. The Deming Application Prize is an annual award presented to the companies that have achieved distinctive performance improvements through the application of TQM. Regardless of the types of industries, any organization can apply for the Prize, be it public or private, large or small, or domestic or overseas. The framework is centered on the implementation of a set of principles and techniques, such as statistical methods, quality circles, and process analysis. (Hromi, 1995)

The Deming Application Prize is given to applicant companies or divisions of companies that effectively practice TQM suitable to their management principles, industry, business and scope. More specifically, the following evaluation criteria are used for the examination to determine whether or not the applicant companies should be awarded the Prize:

1. Reflecting its management principles, type of industry, business scope, and business environment, the applicant has established challenging and customer-oriented business objectives and strategies under its clear management leadership.

2. TQM has been implemented properly to achieve business objectives and strategies as mentioned Item 1 above.

3. As an outcome of Item 2, the outstanding results have been obtained for business objectives and strategies as stated in Item 1.

Those who have challenged for the Prize share the feeling that they have had a valuable experience and that the management principle of achieving a business success through quality improvement has really worked. Through witnessing the success of these organizations, many other companies have been inspired to begin their own quest for quality management. Learning from those who went before them, the new practitioners were convinced that quality management is an important key to their business success and that the challenge to attain the Prize can provide an excellent opportunity to learn useful quality methodologies. Thus, quality management has spread to many organizations, its methods have evolved over the years, and they contributed to the advancement of these organizations' improvement activities.

This mechanism that encourages each organization's self-development comes from the examination process of the Deming Prize, though the very process has invited some criticism that the examination criteria for the Deming Prize is unclear. The Deming Prize examination does not require applicants to conform to a model provided by the Deming Prize Committee. Rather, the applicants are expected to understand their current situation, establish their own themes and objectives, and improve and transform themselves company-wide. Not only the results achieved and the processes used, but also the effectiveness expected in the future are subjects for the examination. To the best of their abilities, the examiners evaluate whether or not the themes established by the applicants were commensurate to their situation; whether or not their activities were suitable to their

circumstance; and whether or not their activities are likely to achieve their higher objectives in the future.

The Deming Prize Committee views the examination process as an opportunity for "mutual-development," rather than "examination." While in realty the applicants still receive the examination by a third party, the examiners' approach to evaluation and judgment is comprehensive. Every factor such as the applicants' attitude toward executing Total Quality Management (TQM), their implementation status, and the resulting effects is taken into overall consideration. In other words, the Deming Prize Committee does not specify what issues the applicants must address, rather the applicants themselves are responsible for identifying and addressing such issues, thus, this process allows quality methodologies to be further developed.

In the latest revision of the Deming Prize Guide, the previous examination checklist (1) policy and objectives, 2) organization and its operation, 3) education and dissemination, 4) assembly and disseminating information, 5) analysis, 6) standardization, 7) control, 8) quality assurance, 9) results, and 10) future plans) was changed to "the examination viewpoints," which present the activity guides under TQM values. However, as for the examination criteria, the Committee's basic stance remains unchanged. Namely, the criteria should reflect each applicant organization's circumstance. Companies that have applied for the prize receive a report of the comments and recommendations of the Deming Prize Committee. Reports contain findings about desirable and undesirable aspects of quality operations and include constructive suggestions. (Mahoney, 1994)

As indicated before, the fundamental ideas in Deming's philosophy deal with the understanding and use of statistical tools and change in management attitude. Similar to Six Sigma, Deming emphasizes reducing variation, which requires leadership involving everyone in continuous improvement. Deming's 14 points as shown in Table 1 provides a path for management to follow in order to be competitive in the long run. The program places the responsibility for quality improvement on management and the line workers, not just on quality professionals. (Pyzdek, 2003)

Table 1 Deming's 14 Points for Management.

The Deming's 14 Points for Management
Point 1. Innovate and allocate resources to fulfill the long-range needs of the company and customer rather than short-term profitability.
Point 2. Discard the old philosophy of accepting defective products.
Point 3. Eliminate dependence on mass inspection for quality control; instead, depend on process control through statistical methods.
Point 4. Reduce the number of multiple source suppliers. Price has no meaning without an integral consideration for quality. Encourage suppliers to use statistical process control.
Point 5. Use statistical techniques to identify the two sources of waste-system (85%) and local faults (15%); strive to constantly reduce this waste,
Point 6. Institute more thorough, better job-related training.
Point 7. Provide supervision with knowledge of statistical methods, encourage use of these methods to identify which defects should be investigated for solution.
Point 8. Reduce fear throughout the organization by encouraging open, two-way, non-punitive communication.
Point 9. Help reduce waste by encouraging design, research, and sales pople to learn more about the problems of production.
Point 10. Eliminate the use of goals and slogans to encourage productivity, unless training and management support is also provided.
Point 11. Closely examine the impact of work standards. Do they consider quality or help anyone to do better job? They often act as an impediment to quality.
Point 12. Institute rudimentary statistical training on a broad scale.
Point 13. Institute a vigorous program for retraining people in new skills to keep up with changes in materials, methods, product designs, and machinery.
Point 14. Make maximum use of statistical knowledge and talent in your company.

2.4 ISO 9000 Standards

Regardless of sector, size, structure or maturity, to be successful, organizations need to establish an appropriate quality management system. As Deming (2000) have pointed out only those companies, which can adopt a successful quality management philosophy, can survive in the competitive global markets.

ISO 9000 is considered one of the most popular quality management systems in the world; it has been most widely used (accepted) by firms to impact quality, efficiency, costs and competitiveness. ISO 9000 was originally conceived in 1987. In 1994, the standard was changed, but only around the margins. In 2000, ISO 9000 has again been revised, but this time the new standard called ISO 9000:2000, is a radical revision.

In the literature, ISO 9000 (1994) was criticized for its failure to assess the extent to which a company's planning processes and quality requirements are integrated into the firm's overall business planning and that certification process fails to deal with some aspects of QMS practices such as leadership, strategic planning and employee empowerment. But most importantly, the main criticism center on ISO was that it did not make any implicitly recognizable provisions to improve customer relations, management strategies and practices, and that it does not argue strongly for customer driven organizations. With the introduction of new ISO 9000: 2000 standards many of such criticisms have been eliminated.

The new ISO standard produced increasing focus on planning, especially around development and measurement of quality objectives. It establishes and promotes effective continual improvement based on monitoring and analyzing customer satisfaction.

According to Watson (2002), under the new standard it won't be enough for an organization simply to measure customer satisfaction, organizations will need to improve the level of satisfaction. Organizations will also have to measure and improve internal processes. In other words, the power of customer is obvious in the new standard. The new ISO 9000 standard also produced increasing focus on the role of top management,

particularly around communication. Executive management play a central role with the new standard, and their responsibility is expanded.

The new ISO 9000 standard is based on a Process Model that any effective enterprise can use whether they manufacture parts, process chemicals or provide services. The process model is composed of four sections: section 5: Management responsibility, section 6: Resource management, section 7: product realization and section 8: measurement, analysis and improvement. The other sections (Section 0-3) provide background and section 4: Quality Management system is a precursor to the process model itself, describing the organization's obligations in establishing a documented QMS.

Sections 0-3 provide background information to QMS requirements needed to achieve certification. Definitions of the terms used in the family of standards are provided here. Without understanding of the terms, the standard is prone to misinterpretation.

Section 4 of ISO 9001 contains the basic requirements for establishing a management system rather than any particular component of the system. It emphasizes the principle actions necessary to develop, implement, maintain and improve such a system. Under this section, organizations are required to identify the processes needed for the quality management system and their application throughout the organization.

Under **section 5** top management is required to provide evidence of its commitment to the development and implementation of the QMS and continually improving its effectiveness. Top management is required to establish quality policy, quality objectives and ensure availability of resources. They are also required to communicate to the organization the importance of meeting customer, statutory and regulatory requirements, and establishing customer satisfaction.

Section 6 resource management is a key business process in all organizations. Under this section, organizations are required to determine all the resources needed to implement and maintain the QMS, continually improve its effectiveness and enhance customer satisfaction by meeting customer requirements. This includes human resources: personnel

performing work affecting product quality to be competent on the basis of appropriate education, training, skills and experience.

Under **section 7** organizations are required to plan and develop the processes required for product realization. The product realization processes are needed to identify, create and supply the product or service. These processes take the input from the marketing process through the chain of related processes that deliver products or services to customers. The standard requires these processes to be consistent with the other requirements of the organization's QMS.

Under **section 8**, organizations are required to plan and implement the monitoring, measurement, analysis and improvement processes needed to demonstrate confirmatory of product. Measurement, analysis and improvement processes are vital to the achievement of quality and customer satisfaction. Organizations are required to monitor information relating to customer perception as to whether the organization has met customer requirements, and to collect and analyze appropriate data to demonstrate suitability and effectiveness of the QMS, and to evaluate where continual improvements can be made.

With the introduction of the new ISO 9000 series, ISO 9000 guidelines have been interpreted as an operational definition of Quality Management System (QMS). It is cited as a template for establishing organizational QMS evaluation, and to provide a systematic approach for evaluating all integrated aspects of the business effectively. Hence, it is recommended to use ISO 9000 guidelines for supplier QMS evaluation throughout the literature.

According to Toni and Nassimbeni (2003), success of an organization's business depends on its ability to set guidelines for supplier evaluation and selection, and recommended ISO 9000 guidelines to be used when evaluating supplier's quality capability. They indicated that ISO 9000 guidelines link certification requirements to quality related corporate issues, and can be used as a screening tool for companies when assessing supplier process conformance. ISO 9000 identifies the basic attributes of an

organization's quality management system and specifies practical procedures and approaches to ensure that its products and services are produced in accordance with the process standards specified by the firm. Therefore, using ISO 9000 guidelines can help organizations to identify any discrepancies between what suppliers actually do and what documentation states being done. (Van der Wiele and Williams, 2000) In cases when a discrepancy exists, there are three possible actions for suppliers:

1. Retrain appropriate employees, wit respect to their process activities.
2. Change the documentation to reflect what employees are actually doing
3. Reengineer the entire process, retrain the employees, and change the documentation.

According to Tummala and Tang (2001), the best way to recognize the character of the ISO 9000 process is to relate it to the concept of Total Quality Management (TQM). ISO 9000 describes and defines the fundamental nature of work processes necessary for an organization to achieve the objectives of TQM. Thus, ISO 9000 is critical first step in implementing a TQM system.

However, many important areas of quality management are still believed to be not addressed by ISO 9000 guidelines. Factors such as leadership, human resources management are not being fully explored (Grandzol and Gershon, 1997), and ISO 9000 has been criticized for the fact that, although it can provide an indicator that a supplier has complied with process requirements, it cannot guarantee that the supplier produces quality products. In other words, ISO 9000 ensures that a quality system is in place but provides no absolute measures of quality results. (Tummala and Tang, 2001) In addition, it fails to fully assess to what extent supplier's planning processes and quality requirements are integrated into the overall business planning, and business results. This criterion is particularly important for companies evaluating a supplier for potential long-term partnering relationship. In such cases, purchasing firms are required to determine whether the supplier is integrating quality requirements into overall business strategy

development, business decisions, and innovation in all aspects of company operations, thereby making it a viable long-term partner.

In addition, ISO 9000 does not address a company's approach to selecting data and information for competitive comparisons and world-class benchmarks to support quality and performance planning, evaluation, and improvement. Most importantly, ISO 9000 makes no provisions for continues improvement, and operational and financial results of the supplier are believed to be not evaluated if ISO 9000 guidelines are used. (Van der Wiele and Williams, 2000)

It is therefore suggested in the literature that ISO 9000 can be helpful for purchasing organizations seeking to evaluate supplier quality as an important initial step in the supplier selection process. In particular, ISO 9000 criteria can be useful as a pre-qualifying instrument for documenting processes of suppliers. However, in tracking supplier's business performance, and evaluate overall quality management system of a supplier a broader set of criteria is needed. (Park, Hartley and Wilson, 2001)

The award criteria for MBNQA, on the other hand, provide comprehensive framework within which an evaluation of suppliers' quality systems may be conducted. The following section discusses MBNQA criteria and its application as supplier evaluation tool.

2.5 Malcolm Baldrige National Quality Award

The Malcolm Baldrige National Quality Improvement Act of 1987 created an annual quality award for the United States, launching a national quality improvement initiative.

Since 1987, the comprehensive set of criteria used to evaluate award applicants has become the standard by which many US companies measure themselves. The award criteria and score for each category have been reviewed over the years. (Gillian, 2002)

The seven categories of the criteria consist of 24 examination items addressing common guidelines to TQM principles. The categories and items of the Baldrige Criteria are

shown in Table 2. The total point value, 1000, is distributes among the seven categories according to the point values shown in this table.

The Baldrige Award Criteria provide a systems perspective for managing an organization and its key processes to achieve results—performance excellence. The seven Baldrige Categories and the Core Values form the building blocks and the integrating mechanism for the system. The scoring guidelines are powerful assessment instruments that help organizations identify organizational strengths and key opportunities for improvement. In addition, the Criteria have three important roles in strengthening U.S. competitiveness:

- To help improve organizational performance practices, capabilities, and results.
- To facilitate communication and sharing of best practices information among U.S. organizations of all types.
- To serve as a working tool for understanding and managing performance and for guiding organizational planning and opportunities for learning.

The seven categories of Malcolm Baldrige Award are placed together to emphasize the importance of a leadership focus on strategy and customers. Senior leaders set organizational direction and seek future opportunities for the organization. Human Resource Focus, Process Management, and Business Results represent the results triad. Organization's employees and key processes accomplish the work of the organization that yields the business results. All actions point toward Business Results—a composite of product and service, customer and market, financial, and internal organizational performance results, including human resource, governance, and social responsibility results. The horizontal arrow in the center of the framework links the leadership triad to the results triad, a linkage critical to organizational success. Furthermore, the arrow indicates the central relationship between Leadership and Business Results. The two-headed arrows indicate the importance of feedback in an effective performance management system. (Gillian, 2002) The dynamic relationships of these 7 categories are shown in Figure 2. (Porter and Tanner, 2004)

Organizational Profile (top of Figure 2) sets the context for the way an organization operabtes. The environment, key working relationships, and strategic challenges serve as an overarching guide for an organizational performance management system. The system operations are composed of the six Baldrige categories in the center of the figure that define the operations and the results achieved.

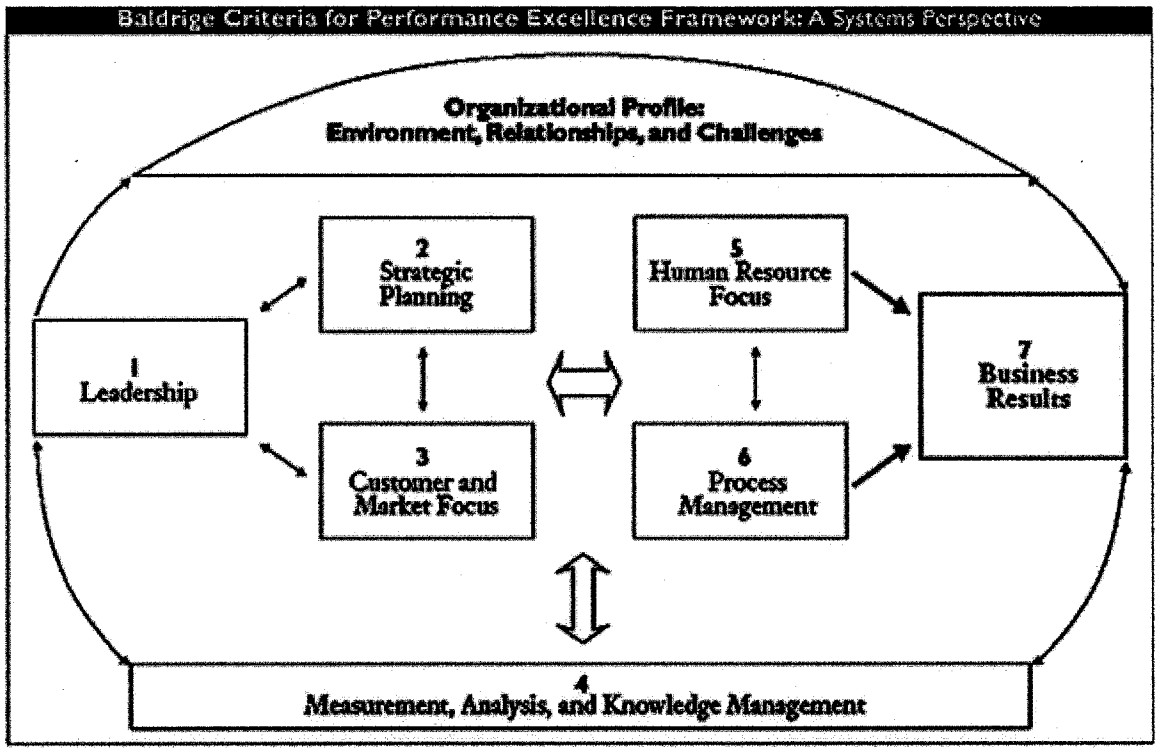

Figure 2 Baldrige Criteria for Performance Excellence Framework.

The categories and items of the Baldrige criteria are summarized next. Point values (totaling 1000 – see Table 2) are assigned to each of the examination categories to help in quantifying the evaluation process. (Blazey, 2004)

Category 1, Leadership, examines how senior executives create and sustain a customer focus, clear values and expectations, and a leadership system promoting performance

excellence within the organization. Leadership's role in executing its public responsibilities and corporate citizenship and how they are integrated into the values and expectations is examined as well.

Category 2, Information and Analysis, addresses how well the use of data and information is managed by the organization and how the data and information support customer-driven performance excellence and marketplace success.

Category 3, Strategic Planning, examines how the organization develops and achieves its strategies and business plans by setting strategic direction and determining key plan requirements.

Category 4, Human Resource Development and Management, evaluates the effectiveness of the organization's development and use of its work force. The organization's efforts to build and maintain a supportive environment are evaluated as well.

Category 5, Process Management, examines how well the key processes including product and service delivery processes, support services, and supply management are designed managed and improved to attain better performance and customer focus.

Category 6, Business Results, evaluates the organization's performance improvement and performance levels relative to competitors in key business areas including product and service quality, productivity, and operational effectiveness, supply quality, and financial performance indicators linked to these areas.

Category 7, Customer Focus and Satisfaction, examines primarily the organization's systems for customer learning and for building and maintaining customer relationships. The levels and trends relative to competitors in key measures of business such as customer satisfaction and retention, market share, and satisfaction are also examined.

Table 2 MBNQA Criteria Scoring.

CRITERIA FOR PERFORMANCE EXCELLENCE — ITEM LISTING
Leadership 120 1.1 Senior Leadership **70** 1.2 Governance and Social Responsibilities **50**
Strategic Planning 85 2.1 Strategy Development **40** 2.2 Strategy Deployment **45**
Customer and Market Focus 85 3.1 Customer and Market Knowledge **40** 3.2 Customer Relationships and Satisfaction **45**
Information and Analysis 90 4.1 Measurement, Analysis, and Review of Organizational Performance **45** 4.2 Information and Knowledge Management **45**
Human Resource Focus 85 5.1 Work Systems **35** 5.2 Employee Learning and Motivation **25** 5.3 Employee Well-Being and Satisfaction **25**
Process Management 85 6.1 Value Creation Processes **45** 6.2 Support Processes and Operational Planning **40**
Business Results 450 7.1 Product and Service Outcomes **100** 7.2 Customer-Focused Results **70** 7.3 Financial and Market Results **70** 7.4 Human Resource Results **70** 7.5 Organizational Effectiveness Results **70** 7.6 Leadership and Social Responsibility Results **70**
TOTAL POINTS 1000

The Baldrige Award Criteria are built upon the following set of interrelated Core Values and Concepts. These core values and concepts that are the foundation for integrating the overall customer and company organizational performance requirements are described below in detail (Porter and Tanner, 2004):

Visionary Leadership: an organization's senior leaders should set directions and create a customer focus, clear and visible values, and high expectations. The directions, values, and expectations should balance the needs of all stakeholders. Leaders should ensure the creation of strategies, systems, and methods for achieving performance excellence, building knowledge and capabilities, and ensuring organizational sustainability. Senior leaders should inspire and motivate an entire workforce and should encourage all employees to contribute, to develop and learn, to be innovative, and to be creative. Senior leaders should serve as role models through their ethical behavior and their personal involvement in planning, communications, coaching, development of future leaders, review of organizational performance, and employee recognition. As role models, they can reinforce ethics, values, and expectations while building leadership, commitment, and initiative throughout the organization.

Customer-Driven Excellence: quality and performance are judged by an organization's customers. Thus, an organization must take into account all product and service features and characteristics that contribute value to customers. Such behavior leads to customer satisfaction, retention and loyalty, and business expansion. Customer-driven excellence has both current and future components: understanding today's customer desires and anticipating future customer desires and marketplace potential.

Customer-driven excellence means much more than reducing defects and errors, merely meeting specifications, or reducing complaints. It is to retain customers and building customer relationships. Customer-driven organizations address not only the product and service characteristics that meet basic customer requirements but also those features and characteristics that differentiate products and services from competing offerings.

Customer-driven excellence is thus a strategic concept. It is directed toward customer retention and loyalty, market share gain, and growth. It demands constant sensitivity to changing and emerging customer and market requirements and to the factors that drive customer satisfaction and loyalty. It demands listening to customers. It demands anticipating changes in the marketplace. Therefore, customer- driven excellence demands awareness of developments in technology and competitors' offerings, as well as rapid and flexible response to customer and market changes.

Organizational and Personal Learning: achieving the highest levels of business performance requires a well-executed approach to organizational and personal learning. Organizational learning includes both continuous improvement of existing approaches and significant change, leading to new goals and approaches. Learning needs to be embedded in the way an organization operates. This means that learning (1) is a regular part of daily work; (2) is practiced at personal, work unit, and organizational levels; (3) results in solving problems at their source ("root cause"); (4) is focused on building and sharing knowledge throughout an organization; and (5) is driven by opportunities to effect significant, meaningful change.

Organizational learning can result in (1) enhancing value to customers through new and improved products and services; (2) developing new business opportunities; (3) reducing errors, defects, waste, and related costs; (4) improving responsiveness and cycle time performance; (5) increasing productivity and effectiveness in the use of all resources.

Employees' success depends increasingly on having opportunities for personal learning and on practicing new skills. Organizations invest in employees' personal learning through education, training, and other opportunities for continuing growth and development. Personal learning can result in (1) more satisfied and versatile employees, (2) organizational cross-functional learning, (3) the building of organization's knowledge assets, and (4) an improved environment for innovation.

Valuing Employees and Partners: an organization's success depends increasingly on the diverse backgrounds, knowledge, skills, creativity, and motivation of all its employees and partners.Valuing employee means committing to their satisfaction, development, and well-being. Increasingly, this involves more flexible, high-performance work practices tailored to employees with varying workplace and home life needs.

Organizations need to build internal and external partnerships to better accomplish overall goals. Internal partnerships might include labor-management cooperation. External partnerships might be with customers, suppliers, and education organizations. Strategic partnerships or alliances are increasingly important kinds of external partnerships.

Successful internal and external partnerships develop longer term objectives, thereby creating a basis for mutual investments and respect. Partners should address the key requirements for success, means for regular communication, approaches to evaluating progress, and means for adapting to changing conditions.

Agility: success in globally competitive markets demands agility— a capacity for rapid change and flexibility. E-business requires and enables more rapid, flexible, and customized responses. Businesses face ever-shorter cycles for the introduction of new/improved products and services, as well as for faster and more flexible responses to customers. Major improvements in response times often require simplification of work units and processes or the ability for rapid changeover from one process to another. Cross-trained and empowered employees are vital assets in such a demanding environment.

Focus on the Future: in today's competitive environment, creating a sustainable organization requires understanding the short- and longer term factors that affect business and marketplace. Pursuit of sustainable growth and market leadership requires a strong future orientation and a willingness to make long-term commitments to key stakeholders—customers, employees, suppliers and partners, stockholders, the public, and your community.

An organization's planning should anticipate many factors, such as customers' expectations, new business and partnering opportunities, employee development and hiring needs, the increasingly global marketplace, technological developments, changes in customer and market segments, community and societal expectations, and strategic moves by competitors.

Managing for Innovation: innovation means making meaningful change to improve an organization's products, services, processes, and operations and to create new value for the organization's stakeholders. Innovation should lead an organization to new dimensions of performance. Innovation is no longer strictly the purview of research and development departments; innovation is important for all aspects of your business and all processes.

Organizations should be led and managed so that innovation becomes part of the learning culture. Innovation should be integrated into daily work and should be supported by the performance improvement system.

Management by Fact: organizations depend on the measurement and analysis of performance. Such measurements should derive from business needs and strategy, and they should provide critical data and information about key processes, outputs, and results. Many types of data and information are needed for performance management. Performance measurement should include customer, product, and service performance; comparisons of operational, market, and competitive performance; supplier, employee, cost, and financial performance.

Social Responsibility: an organization's leaders should stress responsibilities to the public, ethical behavior, and the need to practice good citizenship. Leaders should be role models for organizations in focusing on business ethics and protection of public health, safety, and the environment. Also, organizations should emphasize resource conservation and waste reduction at the source.

Organizations should not only meet all local, state, and federal laws and regulatory requirements, but they should treat these and related requirements as opportunities for improvement "beyond mere compliance." Organizations should stress ethical behavior in all stakeholder transactions and interactions.

Leadership as a corporate citizen also entails influencing other organizations, private and public, to partner for these purposes. Managing social responsibility requires the use of appropriate measures and leadership responsibility for those measures.

Focus on Results and Creating Value: an organization's performance measurements need to focus on key results. Results should be used to create and balance value for key stakeholders—customers, employees, stockholders, suppliers and partners, the public, and the community.

As described before, the MBNQA address many company operations, processes, strategies, and requirements. MBNQA criteria monitor what activities are going well, those which have stagnated, and what needs to be improved throughout the organization. Thus, it provides a well–defined model for evaluating organizational QMS performance. (Tummala and Tang, 2002)

As noted by Gillian (2002), there are many significant benefits derived from using MBNQA as a framework for QMS evaluation. One of the greatest is that the award criteria constitute a comprehensive framework of the total quality conceptual principle, and it can help organizations to "focus improvement where most needed", it synthesized from many different business perspectives and therefore are not limited to a single viewpoint. Hence, continues improvement is a significant benefit of the Baldrige criteria. In each of the major criteria items, companies are asked how they plan to improve in that area.

In addition, the MBNQA argues strongly for customer driven organizations; it recognizes that suppliers will not be able to survive the global market if they cannot guarantee their customers that the product or services provided is as promised. It also requires evidence of this support in criteria items. These items measure how the firm provides effective

management of its relationships with its customers and uses information gained from customers to improve customer relationship management strategies and practices. They also describe the company's commitments to customers regarding its products and services. These items also measure the company's methods for determining customer satisfaction. (Watson, 2002)

As a result, literature suggest once a supplier is pre-qualified and its processes are established, purchasing firms should use measures contained within the MBNQA framework to monitor supplier QMS performance. (Degraeve and Roodhooft, 1999) In addition, Lee and Baskerville (2003) suggest as supplier seeks to progress toward its quality improvement objectives, the MBNQA criteria can provide an indication of the effectiveness of suppliers' efforts to reengineer processes and ensure that initiatives are carried across functional boundaries.

Although literature suggests that the MBNQA criteria can be used to evaluate suppliers its effectiveness as a supplier evaluation tool has not been empirically tested. The major criticism for using MBNQA criteria for supplier performance evaluation has been that MBNQA is long and complicated. It can take an organization 15 to 25 hours to assess supplier performance using MBNQA criteria. Second, there is no adequate database containing quality related information available for companies to compare results from their suppliers. Finally, the relationship between QMS criteria and organizational performance has not been confirmed yet, despite the number of empirical studies conduced.

2.6 Comparison Between Quality Systems

2.6.1 Comparison of Deming Prize and Baldrige Award

Several studies have been conducted to compare the characteristics of the Deming Prize with the Baldrige Award framework (Tummala and Tang, 2002; Mahoney, 1994). The following lists are the similarities and the differences between the Deming Prize and the Baldrige Award.

The Similarities: Both awards emphasize the concept of company wide quality control. Both look for quality commitment throughout the organization, from the top down, including anyone with a relationship with the company such as suppliers, distributors, and customers. They both specifically examine such topics as:

1. How policy is established, employee awareness of policy, and continuous improvement of policy.
2. Short and long term planning methods.
3. Management responsibility.
4. Programs and results of internal employee training.
5. Collection methods and distribution of information.
6. Techniques for quality analysis and the usage of results obtained.
7. Control of capital resources and process.
8. Quality improvement techniques.

The Differences: Unlike the Baldrige Award, the Deming Prize does not provide a model framework for organizing and prioritizing criteria. Deming Prize places more emphasis on process control and improvement. On the other hand, customer and market knowledge get relatively less consideration.

One major difference is in the purpose of the Deming Prize: "To award the prize to those companies that are recognized as having successfully applied companywide quality control based on statistical quality control and are likely to keep up with it in the future." Therefore, most Deming Prize criteria are confined to the application of statistical techniques. On the other hand Baldrige Award has very few mentions of specific statistical techniques. Customer perception of and input to product quality is evaluated for both awards. However, the Baldrige Award emphasizes it much more in its criteria than does the Deming Prize.

2.6.2 Comparison of ISO 9000 and Baldrige Award

Today, many companies doing international business have used the MBNQA criteria and ISO 9000 as tools to achieve quality management. Researchers have been investigating

the differences between MBNQA criteria and ISO 9000. First of these differences is in the Business Results section of the MBNQA. ISO 9000 does not address a company's approach to selecting data and information for competitive comparisons and world-class benchmarks to support quality, and performance planning, evaluation and improvement.

ISO 9000:2000 has least impact on human resource criteria. The standard requires the organization to identify competence, provide training and evaluate effectiveness of that training. It also places requirements for the communication of issues relating to individuals' contribution to the achievement of quality objectives. Meeting these requirements can partly contribute to the areas considered under MBNQA criteria for human resource. The ISO standard does not address many other aspects covered by this criterion, including wider aspects of human resource planning, team working and development of people other than by training, the involvement and empowerment of people, and the issues of reward, recognition and care.

2.6.3 Comparison of ISO 9000 and Six Sigma

One of the key differences between ISO 9000 and Six Sigma is in their basic processes. While ISO 9000 takes a program view, Six Sigma uses a project view, focusing on one specific issue at a time. On the other hand, there many tools that are common to both methodologies such as FMEA, Scatter diagrams, Pareto charts, DOE, histograms, etc. The need of management involvement and commitment, getting everyone within the organization involved, and using customer feedback are also called out in both Six Sigma and ISO 9000.

2.7 Organizational Performance Measurement

The purpose of any organization is to successfully achieve its goals and objectives. To remain competitive these goals need to be achieved in the most effective and efficient manner possible. Performance measurement is the quantification of the efficiency and effectiveness of the organization's actions. In other words, performance measures are metrics used to quantify performance. (Simpson, Siguaw and White, 2002)

Performance measurement involves collection of information and data to analyze performance. To do this, companies design or adopt measures that provide valuable information about the current performance levels of the organizational activities. Organizations utilize various methods to measure their performance level, and the performance level of their suppliers. Literature suggests traditional supplier performance evaluation models include product quality, logistics performance and cost (Dickson, 1966; Weber, Current and Benton, 2002; Kannan and Tan, 2002). The following section discusses these items (quality, delivery and cost) as it is presented in the literature.

2.7.1 Quality Performance

Throughout the years the term *quality* meant different things to different people. A quality product might be one that has no defects and works exactly as customer expects. Such a definition would fit with the definition by Juran (1979): "Quality is fitness for use."

There are other definitions widely discussed: quality as "conformance to specifications" is a position that people in the manufacturing industry often promote. Others promote wider views (Gitlow, 2001; Mann and Kehoe, 1994), which include the expectations that the product or service being delivered 1) meets customer standards, 2) meets and fulfills customer needs, 3) meets customer expectations, and 4) will meet unanticipated future needs and aspirations. Still others simply ignore these definitions and say "I'll know quality when I see it." (Pirsig, 1974)

Hence, summarizing all these definitions, Garvin (1984) describes five ways of looking at quality definitions:

1. Transcendent: Based on this definition, it is not clear what quality is, but it is something good. As Pirsig (1974) suggests, "Quality is neither mind nor matter, but a third entity independent of the two...even through Quality cannot be defined, you know what it is." or as Tuchman (1980) describes," Quality is achieving or reaching for the highest standard as against begin satisfied with the sloppy or fraudulent."

2. Product-based: According to this definition, the product has something that other similar products do not and that adds value. As Abbott (1999) defines it: "Differences in quality amount to differences in the quantity of some desired ingredient or attribute." or as Leifler (1982) describes it: "Quality refers to the amounts of the unpriced attributes contained in each unit of the priced attribute."

3. Customer-based: This definition suggests meeting customer expectations. As Edwards (1998) describes it: "quality consists of the ability to satisfy wants", and the quality of a product depends on how well it fits patterns of consumer preference. Similar definition comes from Gilmore (1994), "Quality is the degree to which a specific product satisfies the wants of a specific consumer." Juran (1979) summarizes all as "fitness for use. Quality is not necessarily a tight tolerance, a shiny surface, or a perfect fit. Quality is satisfying what customer wants, needs and is willing to pay for. Therefore, determining customer's requirements, assessing the ability to meet the requirements and using capable processes are the necessary steps toward achieving quality.

4. Manufacturing-based: This definition suggests conforming to design, specifications, or requirements, and having no defects. As Crosby defines it, quality is a degree to which a specific product conforms to a design or specification. In order quality to happen, it must have a definition that's manageable and measurable. The price of nonconformance (PONC) has to be measured, and then progress or lack of it can be seen. The origin of the problems can be found and this can contribute to the organization's financial success.

5. Value-based: According to this definition, the product is the best combination of price and features. As Broh (1982) defines it "quality is the degree of excellence at an acceptable price and the control variability at an acceptable cost, and as Feigenbaum (1993) suggests, "Quality means best for certain customer conditions. These conditions are (a) the actual use and (b) the selling price of the product."

Other quality experts weighed in with their own definitions of quality. Taguchi (2004) defines quality as "The loss a product causes to society after being shipped, other than any losses caused by its functions." Taguchi points out that many of the customer-based definitions of quality are based on the concept of value to the customer. According to Ishikawa all members of the organization should participate in quality control, and quality should be defined through results of statistical methods. According to him, many firms measure quality as the absence of desirable attributes. Ishikawa calls this backward looking quality. The customer, in contrast, judges quality as the presence of desirable attributes. This is called forward-looking quality. The use of the term quality control implies a backward looking quality philosophy.

These definitions of quality, however, are not based on systematic empirical investigation. Ma (1996) conducted in his empirical research a mix of internal and external measures of quality expressed in financial and non-financial terms. His confirmed research results included external financial measures of quality as warranty repairs, liability claims, lost contribution margins, while internal non-financial measures of quality as the number of defective units, number of customer complaints, and response times. Hence, following the research results in literature, in this research, organizational quality performance will be measured through defect rate (reject/rework rate), customer complaint rate, customer complaint response rate, and quality techniques utilized broadly.

2.7.2 Logistic performance

As just-in-time delivery has become increasingly commonplace and customer demands continue to tighten, the importance of fast, reliable delivery performance cannot be overstated. In today's competitive business environment, customers require dependable on-time delivery from their suppliers. In the short term, delivery deviations—the earliness and lateness from the targeted delivery date—must be analyzed, as both early and late deliveries are disruptive to supply chains. Early and late deliveries introduce waste in the form of excess cost into the supply chain; early deliveries contribute to excess inventory holding costs, while late deliveries may contribute to production stoppages costs and loss of goodwill. It is becoming more common for customers to penalize their suppliers for

early as well as late deliveries (Milgate, 2001). Ballou and Mukherjee (2000) notes that reductions in early deliveries reduced inventory holding costs at Hewlett-Packard by $9 million. In the automotive industry Saturn levies fines of $500 per minute against suppliers who cause production line stoppages. Chrysler fines suppliers $32,000/h when an order is late. When delivery is made on time, however, the costs incurred by the supplier are considered to be "normal costs" and no penalty cost is incurred.

To protect against untimely deliveries, supply chain managers often inflate inventory and production flow time buffers. Correcting untimely deliveries in this fashion represents a reactive management style that may introduce additional sources of variance into the supply chain, and further contribute to the bullwhip effect. In the long run, delivery performance is an important component in the overall continuous improvement of supply chain operations. Recent empirical research has identified delivery performance as one of the key management concerns among supply chain practitioners:

According to Milgate (2001), supplier must have a good manufacturing planning and control systems to ensure timely delivery. While delivery performance is generally recognized as important, a review of literature identified a few attempts to empirically access the extent to which factors impacted performance:

Brown and Vastag (1993) suggested that complexity of internal processes have direct impact on delivery performance. For example, as the number of parts and interconnections increases, production cycle time will be effected, and management is forced to expand the logistical and control processes in place to ensure timely delivery. Changeovers will be harder to do and schedule, moreover, rework is more difficult and lead-time to customer will increase, as the product becomes more complicated, thereby further aggravating delivery performance.

One other factor suggested in the literature effecting delivery performance is product safety stock. According to MacDuffy, Sethuraman and Fisher (1996), the strategic decisions of senior management about the inventory of products can significantly affect the delivery performance. Decreased product inventory increases the challenges in

inventory management, which can increase material stockouts, and in turn decrease delivery performance. According to Brown and Vastag (1993), additional safety inventory for raw material and finished product can improve the reliability of delivery performance by providing a buffer for ever changing customer demands.

Literature suggests supplier customer communication infrastructure plays an important role in improving delivery performance. (MacDuffy, Sethuraman and Fisher, 1996; Lee and Billington, 2002) Establishing inter organizational information systems, such as electronic data interchange (EDI) system, for exchanging data believed to offer flexibility for managing suppliers, provide support for meeting delivery deadlines, and allow the integration of a diversity of information into a unified input that is compatible with the structure and culture of the customer. (Lee and Billington, 2002; MacDuffy, Sethuraman and Fisher, 1996; Flynn, Sakakibarara and Schroeder, 1994)

Another factor suggested by MacDuffy, Sethuraman and Fisher (1996) effecting delivery performance is product variety. According to MacDuffy, Sethuraman and Fisher (1996), product profile increases the level of complexity not only for the production system but also for forecasting and scheduling. Scheduling the production of several variety of products can be a very difficult task often resulting in several schedule revisions, which in turn hurts safety stock and hence delivery performance. However, this factor is not supported by various other researchers (Ellram, 2001; Milgate, 2001) due to fact that it varies based on industry types.

Performing preventive maintenance is another important factor believed to have effect on organization's delivery performance. (Milgate, 2001; MacDuffy, Sethuraman and Fisher, 1996) A study conducted by Milgate (2001) among US manufacturing firms indicates that 73% of the manufacturing firms with preventive maintenance program received high delivery performance rate. 60% of these firms had above 95% machine utilization. Hence, machine availability rate as a percentage of scheduled uptime and mean time between equipment failures are important factors to monitor regularly.

One factor considered but not tested by researchers in the literature is new product launch to market. Sarkis and Talluri (2002) attempted to test the correlation between new product to market delay time and on time delivery rate to customer, but their results were inconclusive.

Taking the results of literature review into consideration it can be determined that measuring delivery performance plays an important part in organizational performance measurement. Hence, in this research delivery performance of an organization will be measured utilizing matters such as production cycle time, change over time, company EDI capability, on time delivery rate, lead time to customer, safety inventory rate, and machine efficiency rate.

2.7.3 *Cost Performance*

According to Pyzdek (2003), a way of increasing profit is through reduction in product costing. Costs are converse of profits. The sum of costs and profits equals sales, or the sum of costs and losses. The usual justification for an increase in cost is increase in sales price, which customers don't want, or accepting reduction in profit, which companies don't want. The idea is to keep the cost low.

According to Pursglove and Dale (2003), one way of keeping the cost low is keeping the cost of quality low. In their empirical research Mathews and Katel (2002) found a positive correlation between cost of quality and organizational profit. Following their research results, in this research cost of quality for an organization is measured as a proxy variable in the place of organizational profit. In other words, to ensure uniform collection of the very sensitive organizational profit information, it was decided to use a proxy variable cost of quality. Proxy variable is one which is hypothesized to be linearly related to the missing variable. According to Durden and Ellis (1995), the validity of proxy relationship can be justified on the basis of theory, common sense, or experience. It cannot be checked directly, because there are no data on missing variable, in this case organizational profit.

The fundamental principle definition of the cost of quality is that any cost that would not have been expended if quality was perfect. Quality cost consist of all those costs associated with company efforts devoted to planning the quality system, to verify that quality is being obtained, and those associated with failures resulting from inadequate systems. There are three categories for measuring quality cost: (Campanella, 1999)

Prevention cost: Those efforts devoted to keeping defects from occurring. Training, capability studies, quality design and planning.

Appraisal cost: Those efforts devoted to maintaining quality levels by means of formal evaluations. Inspection and testing, quality audits, calibration, field testing.

Failure cost: Those efforts devoted to products that don't meet specifications or which fail to meet the customer's requirements. These costs are broken down into internal and external components.

a. Internal failure cost: Costs generated before a product is shipped as a result of nonconformance to requirements. Scrap/Rework, reinspection- retest, process troubleshooting.

b. External failure cost: Costs generated after a product is shipped as a result of nonconformance requirements. Processing of customer complaints, warranty, recalls/returns, unplanned field repair.

In summary, the sum of above costs equal to the total quality cost. It represents the difference between the actual cost of a product or service, and what the reduced cost would be if there were no possibility of substandard service, failure of products or defects in their manufacture.

In this research, cost performance of an organization is measured by determining the cost of quality of the organization. Hence, the questions to be asked include rework/scrap cost, warranty cost, cost spent on quality activities, and training cost.

As indicated previously, traditional organizational performance measures of quality, cost and delivery are considered to be single dimensional and do not provide a comprehensive evaluation of organizational Quality Management System, therefore does not guarantee long term success of an organization.

The following section summarizes the review of literature on the empirical studies conducted exploring the relationship between QMS practices and organizational performance.

2.8 Quality Management System Practices and Organizational Performance

The relationship between QMS practices and organizational performance measures have been investigated in the literature by many researchers:

Flynn, Sakakibara and Schroeder (1994) explored the QMS practices of high, medium and low performing plants based on self-reported yield rates. The results showed that process control was used more often by high than low quality performers. On the other hand, other QMS practices such as employee involvement, and management feedback were used by both high and low quality performers equally high, and medium quality performers used these practices at a lower level. The authors suggested that their results were inconclusive and perhaps low quality performers, aware of their performers, were emulating the practices of high quality performers but had not yet attained the performance benefits.

A survey of Ohio plant managers based on MBNQA found that process quality, human resource management, and information and analysis were positively correlated with self-reported plant performance. Plant performance in this study included measures of quality, technical capability and delivery. No statistically significant relationship was found between plant performance and strategic quality planning, but positive relationship was found between plant performance and process quality, HR management (defined as employee turnover, employee absentee), and information and analysis (Choi and Eboch,1998)

Two studies of QMS practices have focused on automotive suppliers. Ahire and Dreyfus (2000) conducted a survey to automobile component manufacturers in the US. Firms in the study were classified based on their implementation of QMS practices based on MBNQA criteria. The study explored the relationship between QMS implementation and self-reported perceived product quality and delivery performance. The findings showed that compared to non-QMS firms, QMS firms reported higher product quality. In addition, high-performance QMS firms reported a higher intensity of execution on quality practices compared to low performance QMS firms. They also found that process management and human resources practices are both positively related to delivery performance. Delivery performance in their research was descried as improvement in late deliveries, customer complaints due to late deliveries and reduction in production cycle time.

In a follow-up study, data from the US sample were combined with self-reported data from a survey of Canadian automobile components manufacturers (Ahire and Dreyfus, 2000). The results showed greater customer focus, and employee empowerment were related to higher perceived product quality. Although, top management support was not directly related to perceived product quality, the findings suggest that top management commitment affects the implementation of other management practices.

Adam (2001) did a cross-industry survey on quality and productivity management practices based on the MBNQA criteria. Using regression analysis, significant relationships were found between the various QMS criteria (such as process management, human resources focus and management style) and self reported measures of customer satisfaction and quality performance. He also found a significant relationship between plant delivery performance and human resources practices including employee empowerment and employee satisfaction, but no relationship were found between delivery performance and organizational management style.

Grandzon and Gershon (1999) studied the QMS practices used by the US defense contractors from the aerospace, tooling and engineering industries. They found continuous improvement to be positively correlated to operational quality. Operational

quality was a very broadly defined construct that included measures of defect rate, productivity, cycle time, and material usage. In addition, they found a positive relationship between customer focus and customer satisfaction: companies with greater customer focus have higher level of customer satisfaction results. Their study, however, did not conclude a significant relationship between customer satisfaction and human resources practices that included employee empowerment and employee satisfaction.

Dow (1999) measured the relationship between QMS practices and product quality. The data he used were gathered through a survey to manufacturing personnel across manufacturing industries in Australia and New Zealand. In his survey, product quality included the percentage of defects at assembly, warranty costs, and the total cost of quality. He found positive correlation between workforce commitment, shared vision and customer focus and product quality. However, no relationship was found between product quality and information systems and analysis.

Based on a large scale survey of manufacturing companies in the US, Samson and Terziovski (1999) explored the relationship between QMS practices and delivery performance. In his study, delivery performance was represented by on time delivery, and lead-time to customer. Leadership, human resources management, and strategic planning were found to be positively correlated to delivery performance. However, a relationship was not found between delivery performance and process management.

Several empirical studies have measured the relationship between QMS practices and financial performance measures. For instance, Powell (2000) surveyed CEOs of manufacturing companies to measure the relationship between QMS criteria and self reported financial performance. The results showed that having a zero-defect mentality (quality focus), empowering employees, management commitment to quality, and customer focus was positively correlated to perceived financial performance.

Forker (1999) found a positive relationship between human resources management practices and the previous year's return on sales (ROS), but the level of explained variance was low between financial results and information systems and analysis. He

concluded that greater focus on employee will result in benefits in the form of lower operating costs, which in return will result in greater return on sales. He indicated that a consistent combination of quality management practices that are the most effective in contributing to financial performance could not be provided.

In summary, based on the literature review human resource management and process management are the most promising of the QMS practices for improving quality and in increasing delivery performance. However, when considered as a whole, the results of empirical studies of QMS practices and organizational performance are mixed. The findings show no clear direction on which QMS practices lead to improved organizational performance.

Drawing conclusions from existing body of literature for this relationship is challenging for several reasons:

- Most empirical study researchers developed their own measures for quality practices, so the same constructs are often measured using different items in each study.
- Sample size together with industry type differ significantly among these empirical studies
- A variety of different performance measures are used for product quality, delivery performance, and financial performance in each study.

2.9 Conclusion

From the reviewed literature it can be concluded that the greatest stumbling block to quality programs in supply chain systems is in determining what to measure and then developing an appropriate systems to support this measurement. Although single dimensions such as quality, delivery and price (cost) are preferred commonly by many organizations for supplier performance evaluation, the need to consider current purchasing environments has caused present supplier evaluation systems to pay greater

attention to other performance evaluation models. Quality System guidelines and award criteria such as Six Sigma, Deming Prize, ISO 9000 and MBNQA are the most popular quality models that are frequently used by companies. Throughout the literature ISO 9000 and MBNQA were recommended for supplier evaluation, because of the fact that they provide in depth evaluation of supplier's overall QMS performance. On the other hand, both Deming Prize and Six Sigma models were found to be not suitable for QMS evaluation because of the fact that Six Sigma is a project based approach looking for improvements rather than systematic evaluations and Deming Prize does not provide a framework organizations can use to assess themselves.

Although ISO 9000 and MBNQA were recommended for supplier evaluation, both of these models found to have limitations for supplier evaluation. ISO 9000 guidelines are criticized because it fails to fully assess the extent to which a supplier's planning processes and quality requirements are integrated into the firm's overall business planning, and although it ensures a quality system exist in a firm, it does not guarantee its functionality and it does not guarantee product quality.

MBNQA is criticized for its length and complication and that there is no adequate database to compare the results. Several empirical studies were performed to determine the relationship between MBNQA criteria and organizational performance in terms of quality, delivery and financial performance. The results were mixed and inconclusive on what quality management system practices are most likely to improve quality, delivery and firm's financial results. Although relationship between MBNQA criteria and organizational performance was evaluated in the literature broadly, it could not be confirmed. It is also important to note that most of these empirical studies had gathered data on practices and performance from a "within firm" perspective. They did not extend the research into a supply chain context. Thus, resulting a need to study this relationship and to explore the capability of the MBNQA as a supplier evaluation tool.

3. RESEARCH METHODOLOGY

3.1 Introduction

This study is expected to provide a clear understanding of major characteristics of supplier evaluation model. In regards to examining organizational performance, empirical studies have been the predominant research methodology. (Donney and Cannon, 1997; Dow, 1999; Powell, 2000; Samson and Terziovski, 1999) While normative literature and case studies have examined the underlying constructs associated with organizational performance, they have not been very well developed and suffer from a lack of empirical testing. One of the contributions of this dissertation will be to develop further and establish valid measures for the underlying constructs associated with supplier evaluation, which remain largely untested.

Case studies are very useful for building theories and getting to the heart of relationships (Dowdy and Wearden, 1985); however, the results of case studies are often difficult to generalize (Wayne and Terrell, 1995). Large scale empirical testing is useful because standardized measures, which are a necessity for making comparisons, can be used across a broad population in order to make generalizable conclusions (Dillon and Goldstein, 1984) For the purpose of this dissertation, survey method will be used, because a survey is an approved method for setting objectives for information collection, designing research, preparing reliable and valid data collection instrument. Thus, for the purpose of this research most suitable research instrument.

3.2 Research Objective and Hypothesis

The primary objective of this dissertation is to investigate and measure the underlying characteristics of an effective supplier evaluation model. This research will clarify much of the confusion surrounding the relationship between single dimensional supplier performance measurement tools (quality, delivery, cost) and QMS evaluation tools (using MBNQA criteria). Hence, this study will explore if high, medium and low performing suppliers emphasize different bundle of quality management practices, and will identify

which specific practices contribute to the differences. 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 are likely to reap measurable benefits.

The fundamental question to be explored is: *What are the critical characteristics of supplier evaluation model?* In the light of both the strategic importance of supplier performance measurement and quality management system evaluation issues that have been discussed in the literature, it is logical to hypothesize that suppliers that demonstrate same level of organizational performance will exhibit similar quality management system performance. To this extent, the following questions that motivate this research to be answered:

1. Do organizations that demonstrate high level of operational performance also demonstrate high level of QMS performance, i.e. is there a relationship between organizational performance and QMS performance?
   1.1. If so, what organizational performance dimensions play role on this relationship?
2. Do organizational performance dimensions have an influence on QMS criteria?
   2.1. If so, what dimensions are significant in this relationship?
3. Does organizational performance improvement have a direct impact on QMS performance?

To answer these questions, the hypotheses in this research are categorized under four main hypotheses, and twenty-one sub-hypothesis. These are as follows:

Hypothesis 1 and sub-hypotheses 1.1-1.3 are designed to answer question 1 and sub-question 1.1.

H1: There is a relationship between organizational performance and QMS performance.

H1.1. There is a correlation between organizational quality performance and QMS performance.

H1.2. There is a correlation between organizational delivery performance and QMS performance.

H1.3. There is a correlation between organizational cost performance and QMS performance.

Hypothesis 2 is designed to answer question 2 and sub-question 2.1.

H2: Organizational performance dimensions will covary with QMS criteria of leadership, information and analysis, strategic planning, human resource management, process management, customer focus and satisfaction.

Hypothesis 3 is designed to answer Question 3.

H3. Organizational improvement scores will covary, with the QMS performance scores.

3.3 Data Collection

3.3.1 Sample Selection and Consideration

Ideally, in a study to obtain valid results large sample sizes are needed, which makes the administration of questionnaires a timely process. The data were obtained by two questionnaires in this research. The questionnaires were sent out by mail. A common dilemma is caused by the number of questionnaires that must be answered within each organization. To obtain an accurate profile for a company, at least 20 responses are needed from all levels of the company's personnel. (Cohen, 1988) On the other hand, if the data is to be used comparatively rather than in an absolute manner, fewer respondents are required. (Cohen, 1988) In reality, to obtain 20 answers from a single organization is unpractical, and has high potential to reduce the number of companies that would possibly responding to the surveys. The second option in turn allows more companies to be included and improves the validity of comparisons that can be made. Considering the objectives of the dissertation, which is of a comparative nature, the second option is chosen. To further reduce variability, only management (executive) levels are included in the survey.

For the purpose of this research, suppliers of a local 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 local OEM. In addition, a total of 130 tier 1 suppliers of other OEM (original equipment manufacturers) were selected. Tier 1 supplier is defined as a company that supplies its products directly to the final assembler. (Moore, 2002) The 130 tier 1 suppliers to participate in this study were randomly selected from a database, which only contains manufacturing companies in the US.

Two questionnaires, one developed by the researcher (for organizational performance measurement), the other one developed and already tested and verified by Wu (1996), (QMS measurement) were sent to these 300 manufacturing organizations. Both questionnaires were sent at the same time accompanied by an explanatory cover letter via self-addressed pre-paid envelope, requesting response by the executive in charge of operations with overall knowledge of performance throughout the organization.

3.3.2 Demographics

There are two demographic variables that are considered as a control variables in this study: company size, industry type. The use of these variables will be for control purposes. Other demographic factors such as years of ISO 9000 certification, profitability of the organizations, possession of other type of certifications will also be available through the questionnaire sent.

3.4 Measurements

3.4.1 Measurement of Supplier Performance Level

3.4.1.1 Questionnaire Development

In this research, the instrument used to collect the sample information for measuring the underlying constructs of SQL is a self-administered questionnaire.

The questionnaire for supplier performance level measurement will be divided into three sections: quality, delivery and cost sections. The questions in each section are developed after performing extensive literature review, review of benchmark studies and utilizing expert opinions. The following steps were taken:

1) Review of literature on measuring organizational quality, delivery and cost performance. Review of previous research studies. The results of these studies are discussed in the literature review section.

2) Utilize expert opinion: Review of questionnaire with local OEM executives, whose supplier base will be used as the primary sample population of this research – make modifications as recommended.

3) Develop company profile questions. (utilizing mostly benchmark programs, and expert opinions). "Industry type" question was adapted from IW Best plant benchmark program. The SIC code, which identifies groups of common manufacturing processes and technologies, was used to identify the organizations and then the codes were modified per local OEM purchasing manager recommendation to make it more suitable to current OEM supplier base.

4) Develop the final questionnaire of 45 questions.

5) Review of the 45 questions with executives of 15 supplier organizations .The final version ended up with 32 questions.

The first part of organizational performance measurement questionnaire entitled background information, asks (optional) questions describing the organization's background: organization size, industry type, product type, years of ISO 9000 certification. The second part of organizational performance measurement questionnaire, asks questions based on quality, delivery and cost performance of the organizations. There were also questions on other issues likely to have some impact on performance, such as organization's improvement trend, total revenue trend. Each section questionnaire had different point scale. Quality and delivery section answers were on 5 point scale, cost performance answers on a 6 point scale. The Table 3 below shows the organizational performance evaluation questions by category.

Table 3 Evaluation of Organizational Performance Scores by Category.

Category	Questions
Quality	Q1-Q9
Delivery	Q21-Q31
Cost	Q10-Q20

3.4.2 Measurement of Supplier QMS Performance

In her research, Wu (1996) developed an instrument in the form of questionnaire to assist organizations in a self-evaluation of their QMS performance against Baldrige criteria. Based on the content of her questions, it is possible to develop general guidelines for QMS performance evaluation. The questionnaire consists of 31 questions related directly or indirectly to quality issues. The survey asked questions based on MQA criteria (Missouri Quality Award), which are identical to the MBNQA. Her questions were designed with information to the seven categories of MBNQA such as Leadership, Information and Analysis, Strategic Planning, Human Resource Development and Management, Process Management, and Customer Focus and Satisfaction. In this

research, Wu's questionnaire, already tested for validity and reliability, will be used to measure QMS performance of the (supplier) organizations.

To make questionnaires easy to fill out, most answers were of the same type, a 7-point Likert scale, indicating extent to which respondents agreed or disagreed (1= strongly disagree; 7= strongly agree). A "NA" choice (not applicable) was available for each question. To aid in statistical analysis of the data, numerical ratings such as percentages were represented in multiple choice from dividing 100 percentages equally into 7 scales.

Table 4 Evaluation of QMS Scores by Category.

Category	Questions
Leadership	Q1-Q6
Information and Analysis	Q7-Q10
Strategic Planning	Q11-Q14
Human Resource Development and Management	Q15-Q21
Process Management	Q22-Q26, Q28
Business Results	*
Customer Focus and Customer Satisfaction	Q29- Q32

* Due to fact that Wu (1996) indicated companies were unwilling to present data on business results, and similar questions as business results questions in Wu's questionnaire (1996) were included in organizational performance measurement questionnaire, these questions were taken out of QMS evaluation questionnaire.

3.5 Method for Analysis

3.5.1 Internal Validity

Any research is subject to the issue of research credibility which refers to "the simultaneous realization of as much reliability and validity possible" (Miller, 1991).

Validity refers to the degree to which evidence supports the inferences made from scores derived from measurement, or the degree to which the scale measures what is designed to measure (Skeskin, 1984). In other words, validity analysis is a way of verifying performance of questionnaires. It is used to examine whether the items truly measure what they are intended to measure. Content validity and construct validity are two most commonly used methods for this purpose.

Content validity is concerned with the degree to which the items in a survey instrument are representative of a "defined universe" or "domain of content". (Skeskin, 1984) Construct validity is to evaluate whether a scale is an appropriate operational definition of an abstract variable. As Skeskin (1984) points out, these two methods should not be considered distinct types of validity. They simply enable researchers to discuss the types of information that might be considered when determining the validity of inference.

Since items corresponding to the various constructs of the measurement instrument are derived from a comprehensive analysis of literature, content validity is believed to be assured in this research survey. (May, 2002).

The research questionnaire is validated for comprehensiveness and completeness through interviews with industry experts in the management field in a pilot study. Industry experts were chosen from 15 suppliers of the local OEM and were members of their company management board: Quality, Purchasing and Logistics Managers. To each manager the sections of the questionnaire related to his field were given. Feedback regarding the understandability, applicability, clarity and unambiguity of the questions were collected. The following questions were asked:

1. **Would this be an effective tool to assist you in evaluating your supplier performance?**

The purpose of this question was to learn whether this questionnaire survey could be used to assess their suppliers' performance level. 73% of the respondents indicated that they have a similar system in place to evaluate their suppliers, and thought the questionnaire was effective or very effective. None of them considered that this was not a suitable tool for this purpose.

2. **Are the questions clear, easy to understand or would you make any changes on any of the wording?**

The purpose of this question was to learn whether the questions were clear as far as what they were meant to ask. 53% of the respondents provided constructive feedback and recommended to change a total of 13 questions in all sections for wording and/or content. 67% of the respondents suggested combining "improvement" questions under 1 question.

3. **Is the time required to respond to questions reasonable?**

Time is an important factor for any organization. It was therefore decided to include this question to determine if the data to collect was time consuming. 87% of the respondents thought it is time consuming to collect the data but all of them thought it was necessary to collect such data to evaluate their supplier performance.

4. **Based on your industry experience are there any questions you would like to add and/or eliminate from this questionnaire?**

From the original 45 questions, based on the feedback received from industry experts, the number of questions was reduced to 32. 14 questions were taken out, 7 questions were combined under 1 question and 7 new questions were added. The final questionnaire with 32 questions were again sent to these industry experts to get their final opinion / rating (see question 5)

5. If you would use this questionnaire for your supplier evaluation, how would the results compare to the results of your existing supplier evaluation method?

The purpose of this question was to see by using the final questionnaire on their suppliers, whether the companies would obtain same results as if they use their existing supplier evaluation method.

All of the companies tested the questionnaire on their 10 (randomly selected) suppliers. (sub-supplier of the local OEM) 87% of the respondents indicated that up to 80% of their suppliers had matching performance score. 7% indicated that up to 60% of their suppliers had matching score, and remaining 7% indicated that up to 50% of their suppliers had matching score*.

(*Matching score indicate greater than 85% match.)

In addition, the questionnaire was tested against the current supplier rating system of the local OEM. The questionnaire was used on the randomly selected 10 supplier of the local OEM, and their score was compared to their current supplier performance score. All of the suppliers had matching scores to their current supplier performance score.

As a summary, based on the comments from experts (positive constructive feedback), questions and/or their wordings were modified to increase content validity and clarity. This set of modified questions was used to develop final questionnaire. Instead of performing focus group discussion technique to gather experts' opinions on the questionnaire, experts were individually interviewed due to the fact that in focus group discussions it becomes difficult for everyone to be heard, and for the researcher to probe each person to find views and experiences that differ from primary ones expressed. In addition, the difference in background or experience of the experts can be so salient as to make it uncomfortable for people to speak candidly in the group. (Miller, 1991)

The survey instrument will be also tested for its reliability. Reliability is consistency of measurement, which is used to indicate the relationship between the true underlying score and the observable score. (Miller, 1991)

Reliability analysis provides a measure of the ability of the survey instrument to produce consistent results from one administration to the next, or to the degree which measures are free from random error. Although there are a number of methods for measuring reliability, the internal consistency method will be preferred due to the fact that it requires only one administration of the survey, and it is most widely accepted measure. (Daniel and Terrell, 1995) Cronbach's coefficient alpha, which is basically the average of all the correlations between each item and the total score, is often calculated to determine the extent of homogeneity.

The index can range from 0 to 1. The higher the alpha coefficient, the higher the internal consistency and reliability. In other words, the questionnaire must have high reliability so that the questionnaire's score can more accurately reflect underlying dimension. Generally, an alpha value of 0.7 or greater is an acceptable level of reliability (Nunnally, 1978), although May (2002) suggest allowing a lower threshold down to 0.6 or even 0.5. According to Nunnally (1975) a satisfactory level of reliability depends on how a measure is being used. In the early stages of predictive and construct validation, time and energy can be saved using instruments that have only modest reliability such as 0.70. It can be argued that increasing reliabilities beyond 0.80 in basic research is wasteful of time and money. Jobson (1991) suggests the alpha level to be above 0.50 and Nunnally (1975) to be above 0.60 for an exploratory analysis.

In contrast to the standards used to compare groups, a reliability of 0.80 may not be high enough in making decisions for individuals. In such cases, 0.90 is considered bare minimum, and a reliability of 0.95 should be considered the desirable standard. Values for Cronbach's alpha for the multi item constructs corresponding to supplier performance evaluation and QMS assessment are determined.

3.5.2 Test for Homogeneity of Population

3.5.2.1 Effect of Industry Type on QMS and Organizational Performance

The average values for each dimension of QMS performance and organizational performance will be calculated for each industry type. The average values for each dimension will then be compared using Chi-Square test. If no significant differences are identified, then it can be assumed that no significant variation of QMS performance or organizational performance is present in the sample due to industry type differences.

3.5.2.2 Effect of Company Size on QMS and Organizational Performance

The average values for each dimension of QMS performance and organizational performance will be calculated for each company size category. The average values for each dimension will then be compared using Chi-Square test. If no significant differences are identified, then it can be assumed that no significant variation of QMS performance or organizational performance is present in the sample due to company size differences.

3.5.3 Analysis of Data

The entire main and sub hypotheses of this research will be tested using different statistical tools. For all statistical analysis SPSS software Grad Pack 14 will be used.

3.5.3.1 Relationship between Organizational Performance and QMS Performance

The relationship between organizational performance (based on quality, delivery and cost) and QMS performance will be evaluated under hypothesis 1, and the influence of each organizational performance dimensions to QMS performance under sub-hypotheses 1.1 through 1.3. The purpose of these analyses is to determine weather the low, medium and high performing suppliers (as far as organizational performance score) will have same QMS score (H1), and to determine which of the organizational performance dimensions contribute significantly to the QMS performance. (H1.1-H1.3). Regression analysis, ANOVA method will be used for this evaluation. Analysis of variance method can be used to test for the presence of a relationship between two variables. In this

process, the total sum of squares is a measure of the total variability present in the data. If significant relationships identified using ANOVA method, Hypothesis 1 and Hypotheses 1.1-1.3 will be demonstrated to be true, and it can be stated that there is a significant relationship between organizational performance and QMS performance, and organizational performance dimensions influence QMS performance.

In addition, multiple regression analysis, partial correlation method will be used to test the hypothesis 1.1-1.3. Partial correlation method is a measure of the contribution of an individual variable when the other variables are held constant. In computing the partial correlation coefficient between two variables, the influence of one or more other variables will be eliminated. In this case, partial correlation will evaluate the correlation between each organizational performance dimension to QMS performance while holding the other two organizational performance dimensions constant.

3.5.3.2 QMS Criteria Influence on Organizational Performance Dimensions

A canonical correlation analysis will be performed on the two sets of variables; organizational performance dimensions and QMS criteria, to identify any relationship that may exist. Unlike regression analysis where a single dependent variable is analyzed at a time, canonical analysis includes all dependent variables simultaneously. It also takes into consideration possible colinearities that may exist within the variable sets.

If significant relationships identified using canonical correlation analysis, Hypothesis 2 will be shown to be true, and it can be stated that the dimensions of organizational performance influence QMS criteria.

3.5.3.3 Influence of Operational Improvements on QMS Scores

The purpose of this analysis is to determine the relationship between organizations that have been demonstrating improvements over the last two years and the QMS performance (H3).

Regression analysis, ANOVA method will be used for this evaluation to test the relationship between two variables. If significant relationships identified using ANOVA method, Hypothesis 3 will be shown to be true, and it can be stated that the operational improvement influences QMS performance.

4. SAMPLING STATISTICS

4.1 Response Rates

Questionnaires were sent to all 170 suppliers of the local Original Equipment Manufacturer (OEM), out of which 144 responded, out of which 6 were missing significant data, which in result totals to 81% response rate. In addition, the same questionnaires were sent to 130 randomly selected Tier 1 suppliers of various OEM, out of which 11 responded with less than 1% 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.

Due to the fact that response rate from the Tier 1 suppliers was low, data from these eleven organizations will not be combined with the data from hundred –thirty-eight organizations. They will be treated as a separate data set and will be evaluated separately, and will be discussed later in the discussion section, including the comparison of the results of each data set. Limited number of responses from Tier 1 suppliers and heavy response rate from local OEM suppliers lead to believe that the randomness of the sample is voided. However, similar results were observed by Park, Hardley and Wilson (2003) while they were investigating the effect of TQM implementation on financial performance. The researchers sent surveys to Asian automotive suppliers (Korean and Japanese). Although suppliers of both countries have responded, the limited number of responses from Japanese suppliers led the researchers to eliminate their data from the analysis. They did however, evaluated the data separately (although the sample size was limited) and concluded that both results supported the tested hypothesis of positive effect of TQM implementation on financial performance. They generalized their research

beyond the Korean automotive suppliers and concluded that TQM implementation among Asian automotive suppliers have significant effect on financial performance. This type of generalizing involves generalizing to the unsampled portion of the population. According to Lee and Baskerville, in order to generalize the sample points to a sample estimate, certain statistical conditions have to be met. One condition is that sampling has to be done in a randomized way. Park, Hardley and Wilson (2003) believed that due to fact that Korean automotive suppliers were chosen randomly, the sample points can be properly generalized to a valid sample estimate. Because of the fact that random methods were used, the selection is an unbiased representation of the population, and the subject characteristics of the sample will differ from the subject characteristics of the population by the amount of statistical error specified in the sampling procedure.

My research presents similar results: although having the significant portion of the data only from the suppliers of local OEM and randomness of the sample is believed to be voided by not having significant data from Tier 1 suppliers, a generalization can be made beyond the suppliers of local OEM. One significant reason for this generalization is that in my research, Tier 1 suppliers, which were presented with limited data, don't represent the unsampled portion of the population, because there are indeed Tier 1 suppliers among the suppliers of the local OEM and significant data is collected from these companies to represent the remaining Tier 1 suppliers in the population. In addition, generalizability of the data to the measurement depends on whether the requirements of the instrument validation procedure have been satisfied. These requirements involve pretest and pilot studies, content and construct validities, and reliability. Any research is subject to the issue of research credibility which refers to "the simultaneous realization of as much reliability and validity possible" (Maxwell, 2005). The research questionnaire was validated for comprehensiveness and completeness through interviews with industry experts in the management field. To each manager the sections of the questionnaire related to his field were given. Feedback regarding the understandability, applicability, clarity and unambiguity of the questions were collected. Based on the comments from experts, questions and/or their wordings were modified. Since items corresponding to the various constructs of the measurement instrument were derived from a comprehensive

analysis of literature, content validity is believed to be also assured. (Maxwell, 2005). Due to fact that the measurement instrument was validated, the data collected from this research subject will have generalizability to any valid measurement for that population.

Finally, my research is also capable of supporting theoretical generalizations within this study or across different studies because the independent variables are developed and defined clearly and comprehensively through literature review and have identical meaning across different studies. The interviews with industry experts in the management field regarding the understandability, applicability, clarity and unambiguity of the measurement instrument also verify the fact that dependent variables in my research are defined thoroughly and have identical meanings in different studies.

4.2 Demographic Breakdown of the Data

4.2.1 Industry Types

SIC codes were used to classify the industry types. The majority fell into the following seven sub-categories as shown on Table 5 below:

Table 5 Industry Types Breakdown.

Category	Percentage of the Respondents
Rubber and Miscellaneous Plastic Products	29%
Electronic & Other Electrical Equipment	3%
Fabricated Metal Products	16%
Printing and Publishing	4%
Chemicals	6%
Industrial Machinery and Equipment	32%
Other Manufacturing Industries	10%

The breakdown of the organizations participated in the survey are:

Most participants from Industrial Machinery and Equipment (44), following them respondents from Rubber and Miscellaneous Plastic Products (40), Fabricated Metal Products (22), Chemicals & Allied Products (8), Printing and Publishing (6), Electronics & Other Electrical Equipment (4), and Other Manufacturing Industries (14). Other Manufacturing industries were hard to categorize, due to fact that they were representing various types simultaneously.

In addition, the following information was derived from the survey:

61% of the industries were public and 39% were private. As shown in Figure 3, 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).

As shown in Figure 4, 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).

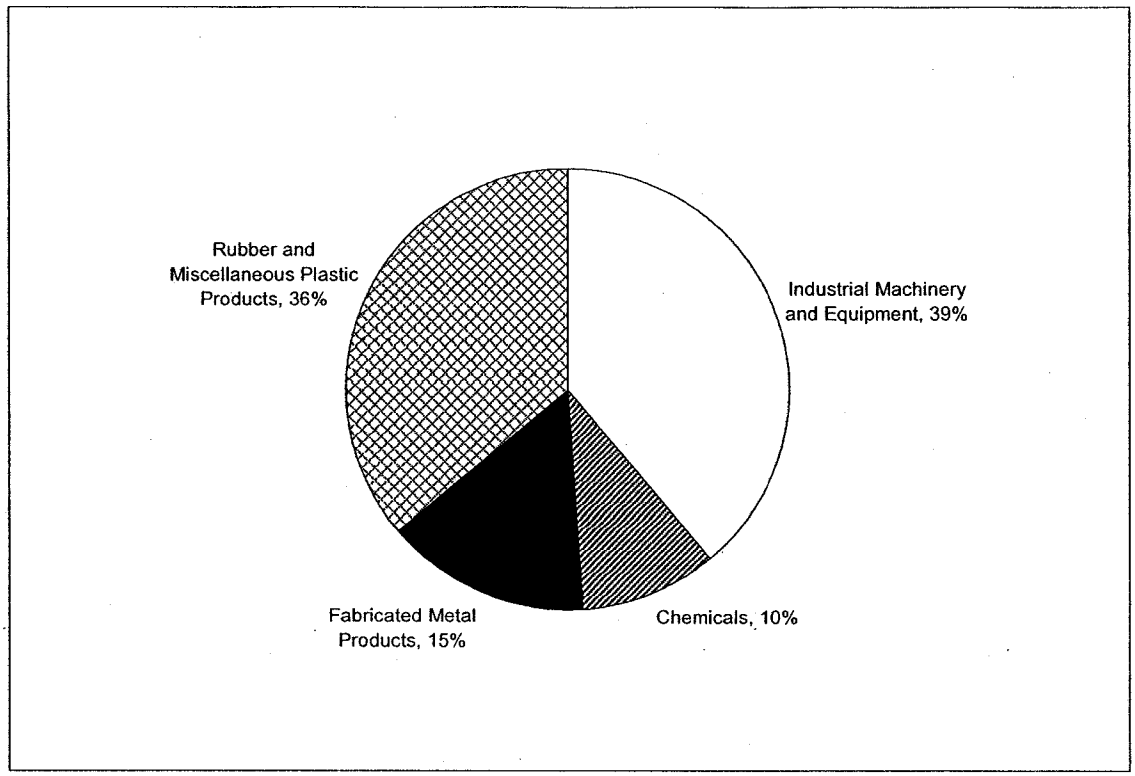

Figure 3 Breakdown of Industries in Public Sector.

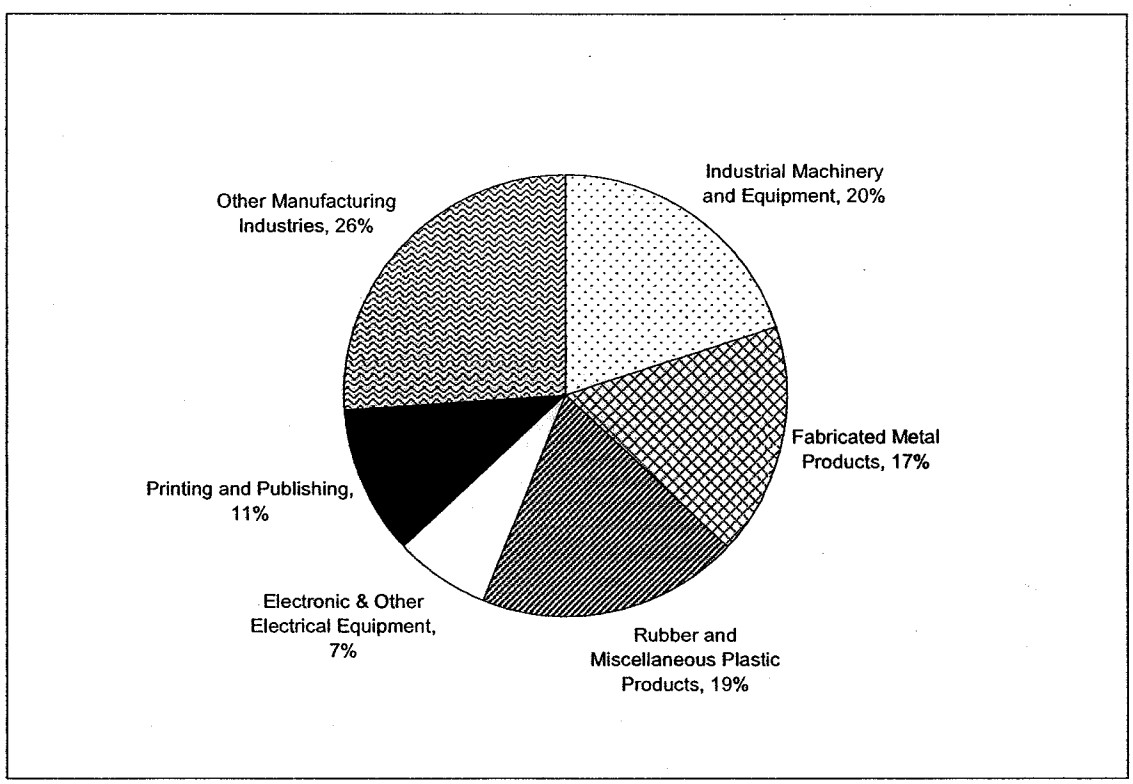

Figure 4 Breakdown of Industries in Private Sector.

4.2.2 Company Size

The size of participating companies is determined based on number of employees working. Company size statistics are shown on Table 6 below.

Table 6 Company Size Breakdown.

Number of Employees	Number of Companies
<100	14%
100-249	11%
250-499	28%
500-999	32%
>1000	15%

As indicated before, 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).

4.2.3 Years of ISO 9000 Certification

Another variable that will be measured is the years of ISO 9000 certification organizations have. Table 7 shows this information.

Table 7 Years of ISO 9000 Certification.

Years of ISO 9000 certification	Number of Companies
1-3	7%
4-7	19%
8-10	27%
11-15	28%
>15	19%

Majority of the participants have between 11-15 years of ISO 9000 certification (39), following organizations with 8-10 years of certification (37), 4-7 years of certification (26), greater than 15 years of certification (26), and 1-3 years of certification (10). In addition to years of ISO 9000 certification, possession of other quality / environmental certifications will be measured: registration to QS 9000 certification and ISO 14000 certification. 32 % of the participants indicated that they were QS 9000 certified, 68% of them indicated they were not. 18% of the participants indicated that they are ISO 14000 certified, 82% indicated they were not.

4.2.4 Other Variables Measured

Two other variables were measured as part of this survey: years since plant start-up and profitability of the organizations. The Table 8 below shows the breakdown statistics for the age of the organizations. In addition, out of the 138 participating organizations 91% of them (126) indicated that they were profitable, 9% (12) indicated that they were not profitable.

Table 8 Breakdown of Years since Plant Start-up.

Years since plant start-up	Number of Companies
1-5	12%
6-10	22%
11-15	20%
16-20	14%
>20	32%

5. ANALYSIS OF DATA

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. Hypothesis 1 -1.3 are tested. In addition, with this approach the impact of organizational performance improvement on QMS performance will be tested – hypothesis 3.

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. Hypothesis 1.1-1.3 are tested.

Canonical correlation analysis will be used as third approach to identify relationships between the sets of dimensions for organizational performance and QMS performance. Hypothesis 2 is tested.

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.

5.1 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 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 9 below.

Table 9 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 determined from Table 9, 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 do also not provide any significant variances to the QMS score in the study.

5.2 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 by May (2002) 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. In attempt to increase the alpha levels of these dimensions reliability tests were reconducted by removing certain questions out of each category. Removing Q31 from Customer Focus category, removing Q3 from Leadership category, removing Q24 from Process Management category and removing Q9 from Information Analysis categories helped to increase the alpha values above 0.70. However, these questions are still believed to be reliable and representing the purpose of the measurement. In addition, they are the original questions from Wu's (1996) research, and valid measurement instruments for the QMS dimensions they are representing. Thus, they are not removed from the original questionnaire.

5.3 Analysis of Data Using Regression Analysis

Two methods of analysis for regression analysis are performed. Both methods are performed using SPSS Grad Pack Version 14.0.

- Anova method to determine the relationship between organizational performance dimensions of quality, delivery, cost, total performance level and QMS score, and to test the impact of organizational performance improvement on QMS performance.

- Multiple regression – partial correlation method to analyze the contribution of each individual organizational performance dimension on QMS score when the other two organizational performance dimensions are held constant.

5.3.1 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. Regression analysis is thought of by many as the most useful of all statistical methods and is often used in an exploratory fashion to look for empirical relationships. In this research it provides yet another way of investigating whether or not a relationship exists between organizational

performance dimensions and QMS score. The analysis contains dependent variable as QMS score and independent variables as quality, delivery and cost to determine the relationships among these categories. To identify the relationship that exist between the dependent variables and independent variables, and also among the independent variables the correlation matrix is analyzed. (Table 10) 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 10. Calculations are shown in Appendix C.

Table 10 Correlation 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

Another key statistics is the t value used to test the null hypothesis that the slope of the regression equation in the population is zero. If regression equation has a slope of zero, a change in dependent variable does not affect independent variable. In other words, dependent and independent variables have no correlation in the population. For the correlation between Quality and QMS and to test the hypothesis H1.1 t statistics is calculated to test the null hypothesis that $\beta_1 = 0$. The null and two tailed alternative hypotheses are:

$H_0: \beta_1 = 0$

$H_1: \beta_1 \neq 0$

The computed t value (10.4) is larger than the critical t value (2.567). Therefore, the null hypothesis is rejected. It is concluded that the population regression line does not have a slope of zero. There is a relationship between Quality and QMS.

For the correlation between Delivery and QMS and to test the hypothesis H1.2 t statistics is calculated to test the null hypothesis that $\beta_1 = 0$. The null and two tailed alternative hypotheses are:

$H_0: \beta_1 = 0$

$H_1: \beta_1 \neq 0$

The computed t value (12.052) is larger than the critical t value (2.567). Therefore, the null hypothesis is rejected. It is concluded that the population regression line does not have a slope of zero. There is a relationship between Delivery and QMS.

For the correlation between Cost and QMS and to test the hypothesis H1.3. t statistics is calculated to test the null hypothesis that $\beta_1 = 0$. The null and two tailed alternative hypotheses are:

$H_0: \beta_1 = 0$

$H_1: \beta_1 \neq 0$

The computed t value (-2.855) is smaller than the critical t value (-2.567). Therefore, the null hypothesis cannot be rejected. It is concluded that the population regression line has a slope of zero. It cannot be concluded that there is a relationship between Cost and QMS, that is in negative nature.

Another 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 11. Calculations are shown in Appendix D.

Table 11 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.

5.3.2 Effects of Organizational Performance Improvement on QMS Performance

Similar method: regression analysis, ANOVA method is used to determine the relationship between organizational performance improvement and QMS performance. The purpose of this analysis is to determine whether organizations that demonstrated improvements over the last 3 years period (based on self reported data) have higher QMS score. The results of the analysis showed significant relationship between performance improvement score and QMS score with a correlation coefficient of 0.827. Calculations are shown in Appendix E.

For the correlation between Improvement and QMS and to test the hypothesis H3 t statistics is calculated to test the null hypothesis that $\beta_1 = 0$. The null and two tailed alternative hypotheses are:

$H_0: \beta_1 = 0$

$H_1: \beta_1 \neq 0$

The computed t value (5.363) is larger than the critical t value (2.567). Therefore, the null hypothesis is rejected. It is concluded that the population regression line does not have a slope of zero. There is a relationship between Improvement and QMS.

5.4 Analysis of Data Using Canonical Correlation Analysis

The third method of analysis performed is Canonical Correlation Analysis. In this method all of the relationships between two sets of variables can be analyzed. SPSS Grad Pack Version 14.0 is used for the purpose of calculation of statistics.

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 in this dissertation:

- 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.

5.4.1 Influence of Organizational Performance Dimensions on QMS Dimensions

The relationship between organizational performance dimensions (quality, cost, delivery) and QMS dimensions (leadership, information and analysis, strategic planning, customer focus and satisfaction, human resources management, process management) is a focal point of the dissertation. It is also one of the more complex relationships being studied / analyzed.

The total QMS score variable is omitted from the canonical correlation analysis. The total score is a composite measure of all of the other QMS dimensions. Using this score leads

to too many collinear relationships being formed during the canonical correlation analysis, making the results difficult to interpret.

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 12. Calculations are shown in Appendix F.

Table 12 Relationship between Organizational Performance Levels and QMS Dimensions.

Canonical Relationship	Canonical Variable	Correlation Between Set 1 & Set 2	Prop. Of variation in set explained	Sum of S2 coefficient
CV1	S1=0.865 DELIVERY	0.751 (0.000)	0.245	
	S2=0.618STRAT+0.532PROC+ 0.472CUST + 0.838 LEAD		0.215	1.128
CV2	S1=0.821QUALITY +0.802 COST	0.854 (0.005)	0.159	0.648
	S2= 0.633 LEAD+0.478 CUST - 0.618 INFO – 0.456 PROC		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. Table 5.4.1 shows the summary of the canonical correlation analysis.

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.

The significance of the determined relationships shows Hypothesis 2 to hold true. The individual Organizational Performance dimensions have an effect on the QMS scores.

6. LIMITATIONS

The limitations of this research can be evaluated in three sections: limitations on research questionnaire, limitations on research methodology and limitations on research dimensions.

6.1 Limitations of the Questionnaire

To measure the QMS level, a questionnaire similar to one developed by Wu (1996) is applied. Judging the QMS level questionnaire is difficult. The dimensions were not designed to be orthogonal, but rather to match results for the Malcolm Baldrige National Quality Award audit. The dimensions used for the MBNQA are not in question here, and consequently neither is the questionnaire if it had been used for its original purpose. Wu (1996) intended the questionnaire to be used by companies that wanted to judge their own quality efforts without having to commission and expensive audit. When used as a survey tool, as it has been in this dissertation, this questionnaire presents difficulties to verify statistically whether the results received are valid and representing Wu's (1996) original intentions. On the other hand, the scale reliability scores as measured by Cronbach's alpha are high, and other measures closely resemble those obtained by Wu. Therefore, it can be accepted that the questionnaire offered acceptable results for this dissertation. The use of this questionnaire as a survey tool, however, remains questionable due to the difficulty in verifying its results.

6.2 Limitations of the Methodology

Two main methods of analysis are performed in this dissertation, regression analysis and canonical correlation analysis. The use of regression analysis is relatively common in the analysis of organizational performance level. The use of canonical correlation analysis is however new to this field. Both methods used in this dissertation have their strengths and weaknesses.

Principle research methodology was chosen as canonical correlation analysis, the weakness in canonical analysis lies in the presentation of the results and the complexity of some of the derived relationships. This makes predicting the influences on any single dependent variable complex, even though a more realistic 'picture' of what is occurring is being presented. However, despite of the complexity, the use of canonical correlation analysis is still highly recommended. With the canonical analysis the integrity of the data is maintained, making it possible to calculate and consequently infer the effects of each of the QMS dimensions used in this dissertation. It also has the advantage over correlation or regression analysis in those secondary influences within a set of variables is considered.

In regression analysis, on the other hand, there is only one dependent variable, and the possible interactions between the other variables in the dependent set are not considered. The interactions between the independent variables on all of the dependent variables are also ignored. It provides, however, a much more simple representation on the relationship of the variables.

The combined use of regression analysis and canonical correlation analysis in this dissertation allowed for the strengths of either method to partially overcome some of the others weaknesses.

Another limitation of this research lies on the sampling method used. Only Tier 1 suppliers of the local OEM were surveyed for this research with proper sample size. Although both questionnaires were sent out to randomly sampled Tier 1 suppliers of other OEM in the US, the response rate was limited (1%) and therefore not included in the data analysis. Hence, the criticism involves generalizing the results of the research to the unsampled portion of the population. This research may be criticized for the fact that the findings are generalized based on not randomly selected sample. According to Lee and Baskerville (2003), in order to generalize the sample points to a sample estimate, certain statistical conditions have to be met. One condition is that sampling has to be done in a randomized way. Although my sample organizations are not chosen randomly, they are believed to be included in the evenly distribution of the population. Because of the fact

that they are also Tier 1 suppliers of the other OEM, they contain same characteristics and are believed to be representing the unsampled portion of the population. Hence, the sample points can be properly generalized to a valid sample estimate. It is also important to note here that the responses received play an important role to make the research robust for this type of generalization. For example, if none of the small size organizations had return the questionnaire, there will be no representation of small size organizations. In that case, we would face the common criticism of generalizing to the unsampled portion of the population. In a case like this (no response from one side of population), further small size organizations would be needed to have proper representation of the population for the small size organizations. However, this is not the case for this research. Thus, proper representation of all size organizations has been available.

6.3 Limitations of the Dimensions

The variables that both questionnaires (QMS level and organizational performance level) are intended to measure can be considered representative in this research. These dimensions are therefore also considered reliable. Similarly, the dimensions used to describe the level of QMS performance are widely accepted. They are based on the MBNQA dimensions, which in itself is a standard by which the dimensions can be judged. These dimensions, however, cannot be considered orthogonal. This makes them cumbersome to use in empirical research, as there is a large amount of colinearity within the set of variables as is demonstrated by the canonical correlation performed in this dissertation. There are however very few other measures of QMS level determination that can be used, and until further dimensions are developed, these prove to be the most useful.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

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 of quality and delivery. By analyzing which criteria contribute most to the performance level some interesting similarities or effects can, however, be found. A summary chart of these effects is presented in Table 13.

Table 13 Summary of Results for Canonical Correlation Analysis.

Increase in Organizational Performance	Increases (QMS level)	Decreases (QMS level)
Delivery	Strategic Planning Process Management Customer Focus Leadership	
Combined Quality & Cost	Leadership Customer Focus	Information and Analysis Process Management
Contrast Quality & Cost	Strategic Planning	Human Resources Management

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 especially 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 are 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. A well established EDI (electronic data exchange) system ensures that delivery lead times are monitored properly and both customer and supplier are informed of the delivery progress correctly and in a timely manner. In addition, a computerized, data driven inventory management system ensures inventory accuracy and transaction efficiency. Thus, all of these contributing to improved Delivery performance.

On 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. These results are well accepted by the literature. Both Deming (2000) and Juran (1979) promoted customer satisfaction as the ultimate goal of organizations. Deming (2000) suggested that the goal of firms should be to constantly improve their services and products for the customers, and Juran (1979) defined quality as fitness for use, or the ability of a service or product to satisfy a customer's needs through employee involvement and empowerment, which is in line with leadership criteria. He suggested that employee involvement and empowerment has a positive impact on customer satisfaction. Through empowerment management avails its workers increased access to information and resources and delegates decision-making. When empowered employees come in contact with customers, workers remain flexible and responsive to satisfying the needs of the customers. Customer satisfaction is portrayed as an important indicator of an organizations overall performance, largely because it is perceived to be a key indicator of a firm's market share and profitability. Following the results of the analysis, Figure 5 demonstrates the process for implementing supplier performance measurement framework within a buying organization.

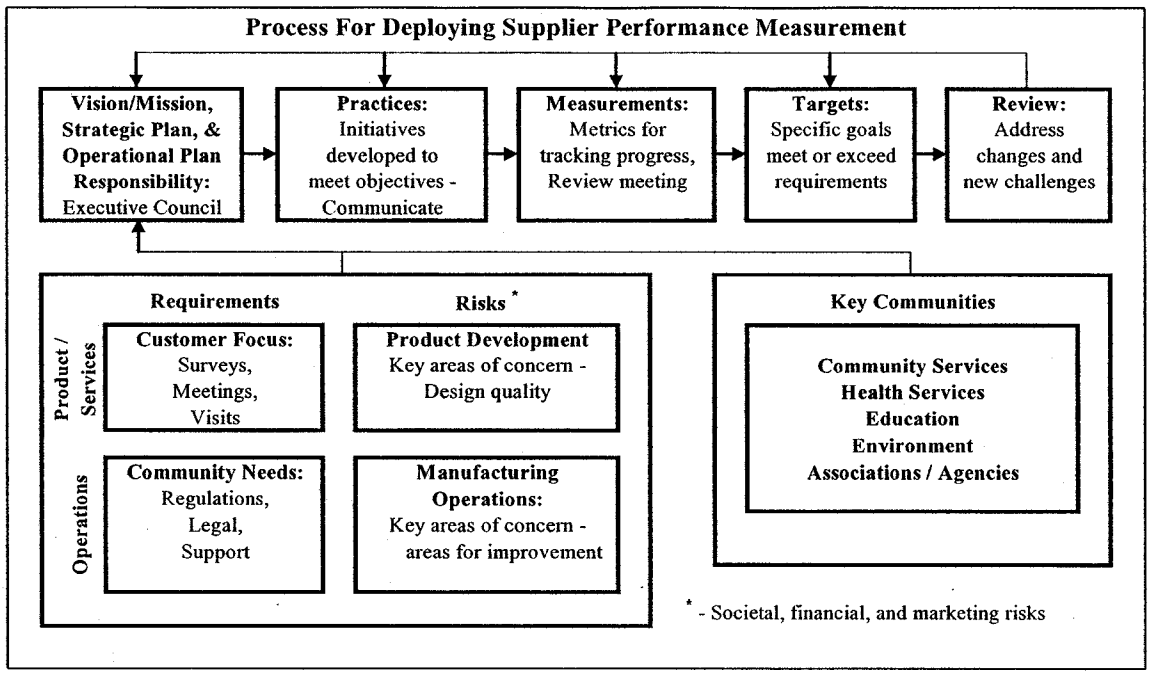

Figure 5 Process for Deploying Supplier Performance Measurement.

Senior leaders should set a clear strategic direction, create a customer service orientation, set clear and visible values and develop high expectations. They should reinforce all these by demonstrating personal commitment to these values, acting as role models for the entire organization. They have direct influence on the performance of the organization.

The quality of company's products and services are judged by the customer. It is therefore important that the key focus of a company's management system is to ensure that customer needs are met. In addition, predicting future customer needs is just as important for long term survival. Customer driven quality is a strategic concept whose measures of successful implementation include customer retention and increase in market share. It goes beyond traditional measures of quality such as defect levels and customer complaints although the effect of these on customer satisfaction must be clearly understood.

Pursuit of market leadership requires a strong future orientation and a willingness to make long-term commitments to all stakeholders. Strategic planning needs to anticipate the many types of changes that will affect customers' future expectations of products and services. Obtaining and keeping competitive edge means increasing the demands on an organization. There will be demands for shorter development times, faster delivery and increased service responsiveness. Major improvements in responsiveness often lead to simplified and more efficient processes and so there are important benefits from this focus.

To ensure high levels of overall performance an organization must seek continually to improve not only its products and services but also in areas such as responsiveness and efficiency to ensure that competitive advantage can be gained and maintained. Improvement can take many forms from small scale team improvement to breakthrough improvement delivering quantum leaps in performance. The cost of preventing problems at a design stage is much lower than the cost of rectification during production or service delivery. It is therefore important to build quality into products. Sometimes, with poor designs, problems are impossible to rectify leading to customer dissatisfaction due to loss of functionality. The long-term damage of this could be irreversible.

Finally, a business management system needs to be built upon a framework of measurement, information, data and analysis. The measurement should be derived from the company's strategy and include all key processes and outputs as a result of the processes. The data required for improvement will be of many types and cover many aspects such as measures of customer satisfaction, product and service performance, and comparison to competitive and against goals. The analysis of the data may be performed in many ways, such as trends, comparisons, and projections. Whatever the analysis method, it is important that the analysis leads to information that drives improvement.

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. Patchwork solutions targeted on an ad-hoc basis at processes may not be effective. Instead, managerial attention should be focused on designing a total system capable of achieving the desired level of performance. 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 steer the organization toward its goals.

The research findings provide a framework for organizational performance measurement and improvement, which is a process of collecting data pertaining to all aspects of the company's activities. It proves that this data can be used to help control and correct waning performance areas and to set new targets for improved performance. It also proves that data can be analyzed to enable appropriate decision making, provide feedback and reinforces behavior, and most importantly, it shows that these measures can be an integral part of continues improvement; and help organizations direct their scarce resources to the most attractive improvement opportunities. In other words, it demonstrates that these measures can be used in the maintenance of long-term focus. In addition, buying firms will be able evaluate their organization's current quality management system against the framework and then use the opportunities for improvement as a guide for continuous improvement.

7.2 Recommendations for Future Research

Extend of the research conducted for this dissertation could be expanded. The relationship model between organizational performance dimensions and QMS criteria, which is based on Tier 1 suppliers of local OEM, could be expanded to include other OEM suppliers. In addition to manufacturing firms, service firms could be included to better distribute the organizations across the supply chain. This would also provide more widespread data, which would allow for a formalization of the model explaining variations in dimensional scores.

Better understanding of this relationship would facilitate the management of organizational performance levels. This in turn would make the implementation of QMS criteria easier. The reverse is also true in that QMS criteria could be better adapted to suit organizational performance levels.

The relationship within any type of organization between QMS criteria and organizational performance could be reinforced. Although sizeable samples were received from the Tier 1 suppliers of the local OEM, more companies from other industries would be required to develop a mathematical model that shows high levels of reliability. It is recommended to work with different buying organizations rather than one. The amount of information is increased using this approach.

A further reinforcement on the QMS dimensions and organizational performance level relationship would be provided by surveying all levels within the companies rather than just managers. It is not expected that this will significantly change the results, which are of a comparative nature, but it would eliminate many critics.

A final recommendation applies to the approach taken in studies involving the effects of organizational performance levels. Although the value of identifying a high performance level would be important, this may be impractical. The effects of performance level are not absolute. Furthermore the effects may be conflicting. In such a situation, a high level performance is hardly noticeable. It is argued that by stressing trends rather than absolutes, models that are more realistic can be developed.

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APPENDIX A

DEMOGRAPHIC COMPARISONS

Effects of Size on Organizational and QMS Performance

Chi-Square Test

Test Statistics

	VARQUAL	VARDEL	VARCOST	VARTOTAL
Chi-Square	3.412	4.734	5.306	4.624
df	4	4	4	4
Asymp. Sig.	.566	.446	.365	.467

a. Grouping Variable: Size

Test Statistics

	VARLEAD	VARINFO	VARSTRAT	VARHR	VARPROC	VARCUST	VARTOTAL
Chi-Square	5.467	1.341	3.206	1.114	5.336	5.628	4.378
df	4	4	4	4	4	4	4
Asymp. Sig.	.404	.765	.685	.964	.419	.398	.527

a. Grouping Variable: Size

Effects of Industry Type on Organizational and QMS Performance

Chi-Square Test

Test Statistics

	VARQUAL	VARDEL	VARCOST	VARTOTAL
Chi-Square	4.947	5.036	5.606	5.924
df	10	10	10	10
Asymp. Sig.	.893	.796	.813	.805

a. Grouping Variable: Industry Type

Test Statistics

	VARLEAD	VARINFO	VARSTRAT	VARHR	VARPROC	VARCUST	VARTOTAL
Chi-Square	10.465	8.434	9.689	9.779	11.248	9.123	8.778
df	10	10	10	10	10	10	10
Asymp. Sig.	.541	.666	.457	.460	.352	.432	.497

a. Grouping Variable: Industry Type

APPENDIX B

RELIABILITY ANALYSIS

ORGANIZATIONAL PERFORMANCE EVALUATION SECTION OF QUESTIONNAIRE

Reliability: Quality

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.848	.865	9

Reliability: Delivery

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.762	.745	11

Reliability: Cost

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.732	.746	11

Reliability: Total Score

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.778	.796	31

RELIABILITY ANALYSIS

QUALITY MANAGEMENT SYSTEM SECTION OF QUESTIONNAIRE

Reliability: Process

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.673	.668	3

Reliability: Strategic Planning

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.720	.730	4

Reliability: Information Analysis

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.603	.593	4

Reliability: Leadership

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.681	.689	6

Reliability: Human Resource

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.837	.840	7

Reliability: Customer Focus and Satisfaction

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.521	.541	4

Reliability: Total Score

Reliability Analysis – Scale (Alpha)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.778	.780	26

APPENDIX C

REGRESSION ANALYSIS

DELIVERY– QMS

Model Summary

Model	R	R Square	Std. Error of the Estimate
1	.906(a)	.822	1.27683

a Predictors: (Constant), VARQMS

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	236.798	1	236.7986	145.249	.000(a)
	Residual	13.0423	168	1.630		
	Total	249.8403	169			

a Predictors: (Constant), VARQMS
b Dependent Variable: VARDEL

Coefficients(a)

Model		Unstandardized Coefficient	t	Sig.
		B		
1	(Constant)	61.229	31.920	.000
	VARQMS	.339	12.052	.000

a Dependent Variable: VARDEL

QUALITY – QMS

Model Summary

Model	R	R Square	Std. Error of the Estimate
1	.976(a)	.953	2.72645

a Predictors: (Constant), VARQMS

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	112,842	1	112,842	64.4	.000(a)
	Residual	101,628	168	1,752.2		
	Total		169			

a Predictors: (Constant), VARQMS
b Dependent Variable: VARQUAL

Coefficients(a)

Model		Unstandardized Coefficient	t	Sig.
		B		
1	(Constant)	1147.9	9.7	.000
	VARQMS	53.8	10.4	.000

a Dependent Variable: VARQUAL

Cost – QMS

Model Summary

Model	R	R Square	Std. Error of the Estimate
1	.739(a)	.0.547	7.14871

a Predictors: (Constant), VARQMS

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	316.6296	1	316.6296	8.1528	.000(a)
	Residual	116.5103	168	38.836		
	Total	433.1399	169			

a Predictors: (Constant), VARQMS
b Dependent Variable: VARCOST

Coefficients(a)

Model		Unstandardized Coefficient	t	Sig.
		B		
1	(Constant)	45.109	5.111	.000
	VARQMS	-.0062	-2.855	.000

a Dependent Variable: VARCOST

APPENDIX D

PARTIAL CORRELATION ANALYSIS

[DataSet0]

DELIVERY – QMS

Correlations

Control Variables			VAR00001	VAR00004
VARCOST & VARQUAL	VARDEL	Correlation	1.000	0.356
		Significance (2-tailed)	.	.003
		df	0	166
	VARQMS	Correlation	0.356	1.000
		Significance (2-tailed)	.003	.
		df	166	0

QUALITY - QMS

Correlations

Control Variables			VAR00004	VAR00003
VARDEL & VARCOST	VARQMS	Correlation	1.000	0.951
		Significance (2-tailed)	.	.000
		df	0	166
	VARQUAL	Correlation	0.951	1.000
		Significance (2-tailed)	.000	.
		df	166	0

COST - QMS

Correlations

Control Variables			VAR00004	VAR00002
VARQUAL & VARDEL	VARQMS	Correlation	1.000	.119
		Significance (2-tailed)	.	.020
		df	0	166
	VARCOST	Correlation	.119	1.000
		Significance (2-tailed)	.020	.
		df	166	0

APPENDIX E

REGRESSION ANALYSIS

ORGANIZATIONAL PERFORMANCE IMPROVEMENT– QMS LEVEL

Model Summary

Model	R	R Square	Std. Error of the Estimate
1	.910(a)	.827	44.33532

a Predictors: (Constant), VARQMS

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	56526.153	1	56526.153	28.757	.002(a)
	Residual	11793.722	168	1965.620		
	Total	68319.875	169			

a Predictors: (Constant), VARQMS
b Dependent Variable: VARIMPRV

Coefficients(a)

Model		Unstandardized Coefficient	t	Sig.
		B		
1	(Constant)	128.038	1.653	.000
	VARQMS	37.829	5.363	.002

a Dependent Variable: VARIMPRV

APPENDIX F

CANONICAL CORRELATION RESULTS

Effects of Organizational Performance Dimensions on QMS Dimensions

Run MATRIX procedure:

Correlations for Set-1

	QUALITY	DELIVERY	COST
QUALITY	1.0000	.8031	.6714
DELIVERY	.8031	1.0000	.7023
COST	.6714	.7023	1.0000

Correlations for Set-2

	LEAD	INFO	STRAT	HR	PROC	CUST
LEAD	1.0000	.3148	.4223	.9897	.4678	.3593
INFO	.3148	1.0000	.4219	.3181	.1534	.1677
STRAT	.4223	.4219	1.0000	.4189	-.0389	.1174
HR	.9897	.3181	.4189	1.0000	.4326	.3582
PROC	.4678	.1534	-.0389	.4326	1.0000	.4367
CUST	.3593	.1677	.1174	.3582	.4367	1.0000

Correlations Between Set-1 and Set-2

	LEAD	INFO	STRAT	HR	PROC	CUST
QUALITY	.3638	.1768	.1254	.3679	.2275	.7124
DELIVERY	.1477	.0923	.2659	.1288	.5378	.0589
COST	.3748	-.1566	.0276	.2915	-.1120	-.1221

Canonical Correlations
1 .751
2 .854
3 .739

Test that remaining correlations are zero:

	Wilk's	Chi-SQ	Sig.
1	.012	78.247	.000
2	.119	34.677	.005
3	.397	14.568	.124

Standardized Canonical Coefficients for Set-1

	1	2	3
DELIVERY	.865	.184	-.347
QUALITY	.052	.821	.653
COST	.084	.802	-.621

Standardized Canonical Coefficients for Set-2

	1	2	3
LEAD	.838	.633	.319
INFO	.016	-.618	.199
STRAT	.618	.179	3.865
HR	-.029	.228	3.118
PROC	.532	-.456	.876
CUST	.472	.478	.714

Canonical Loadings for Set-1

	1	2	3
DELIVERY	.384	.587	-.634
QUALITY	-.338	.499	.493
COST	.985	-.027	-.118

Cross Loadings for Set-1

	1	2	3
DELIVERY	.372	.513	-.515
QUALITY	-.285	.422	.411
COST	.963	-.018	-.086

Canonical Loadings for Set-2

	1	2	3
LEAD	.386	.058	-.322
INFO	.133	.157	.028
STRAT	.027	-.328	-.142
HR	.349	.033	-.384
PROC	.058	.679	.276
CUST	.110	.738	-.476

Cross Loadings for Set-2

	1	2	3
LEAD	.374	.052	-.254
INFO	.130	.148	.021
STRAT	.027	-.291	-.101
HR	.322	.029	-.274
PROC	.051	.564	.211
CUST	.102	.679	-.353

Redundancy Analysis:

Proportion of Variance of Set-1 Explained by Its Own Can. Var.

	Prop Var
CV1-1	.245
CV1-2	.159
CV1-3	.248

Proportion of Variance of Set-1 Explained by Opposite Can.Var.

	Prop Var
CV2-1	.236
CV2-2	.114
CV2-3	.145

Proportion of Variance of Set-2 Explained by Its Own Can. Var.

	Prop Var
CV2-1	.215
CV2-2	.184
CV2-3	.127

Proportion of Variance of Set-2 Explained by Opposite Can. Var.

	Prop Var
CV1-1	.207
CV1-2	.121
CV1-3	.078

APPENDIX G

SURVEY QUESTIONNAIRES

Organizational Performance Measurement Using Malcolm Baldrige Award Criteria
Prepared by Hung-Yi Wu, 1996

Please indicate your choice with an "X"

1. The top management in this organization	**Strongly disagree .....Strongly agree**							
a. has intimate knowledge of how the organization's work gets done	1	2	3	4	5	6	7	NA
b. regularly reviews the quality of work produced	1	2	3	4	5	6	7	NA
c. frequently asks people about ways to improve the work produced.	1	2	3	4	5	6	7	NA
d. follows-up on suggestions for improvement	1	2	3	4	5	6	7	NA
e. has set short-term goals concerning quality improvement	1	2	3	4	5	6	7	NA
f. has set short-term objectives concerning quality improvement	1	2	3	4	5	6	7	NA
2. Managers in this organization	**Strongly disagree .....Strongly agree**							
a. lead by coaching instead of directing	1	2	3	4	5	6	7	NA
b. lead by empowering instead of controlling	1	2	3	4	5	6	7	NA
c. lead by building trust and skill instead of evaluating	1	2	3	4	5	6	7	NA
d. make improving customer satisfaction as the first priority – even more than sales or profits	1	2	3	4	5	6	7	NA
e. at all levels are held responsible for the success or failure of the quality improvement efforts	1	2	3	4	5	6	7	NA
3. The time spent by the top management	**Very little ..... A great deal**							
a. on quality improvement efforts is	1	2	3	4	5	6	7	NA
b. on communicating with customers is	1	2	3	4	5	6	7	NA
c. on communicating with suppliers is	1	2	3	4	5	6	7	NA
d. on communicating with employees is	1	2	3	4	5	6	7	NA
4. The time spent by the middle management	**Very little ..... A great deal**							
a. on quality improvement efforts is	1	2	3	4	5	6	7	NA
b. on communicating with customers is	1	2	3	4	5	6	7	NA
c. on communicating with suppliers is	1	2	3	4	5	6	7	NA
d. on communicating with employees is	1	2	3	4	5	6	7	NA
5. How many work units in this organization	**None ..... All**							
a. have set long-term goals concerning quality improvement	1	2	3	4	5	6	7	NA
b. have set short-term objectives concerning quality improvement	1	2	3	4	5	6	7	NA
c. have defined measures to monitor progress toward reaching quality goals	1	2	3	4	5	6	7	NA

6. How concerned has your organization been with its public responsibilities	**Very little ..... A great deal** 1 2 3 4 5 6 7 NA							
7. How comprehensive is your organization's quality performance data (Comprehensive data should cover internal processes, employees, customers, cost, products/services, suppliers and competitors)	**No data .....All areas** 1 2 3 4 5 6 7 NA							
8. The quality performance data that this organization collects	**Stongly disagree.....Strongly agree**							
a. are tracked over time	1	2	3	4	5	6	7	NA
b. are compared with goals , standards , or objectives	1	2	3	4	5	6	7	NA
c. are compared with competitors	1	2	3	4	5	6	7	NA
d. are used to identify opportunities for quality improvement	1	2	3	4	5	6	7	NA
e. are easily accessed throughout the organization	1	2	3	4	5	6	7	NA
9. How comprehensive is your organization's benchmarking data	**No data .....All areas**							
(Comprehensive data should cover customer-related, product/service quality, internal processes, employee-related, and supplier performance data	1	2	3	4	5	6	7	NA
10.The information on other organizations' practices and performance (benchmarking information) has been used to	**Strongly disagree..... Strongly agree**							
a. improve understanding of processes	1	2	3	4	5	6	7	NA
b. encourage breakthrough approaches	1	2	3	4	5	6	7	NA
c. set " stretch" objectives	1	2	3	4	5	6	7	NA
d. improve strategic planning	1	2	3	4	5	6	7	NA
11.Strategic planning in this organization includes	**Strongly disagree..... Strongly agree**							
a. integration of quality improvement planning into general business planning	1	2	3	4	5	6	7	NA
b. prioritizing quality improvement issues	1	2	3	4	5	6	7	NA
c. employee participation to set goals	1	2	3	4	5	6	7	NA
d. an analysis of the impact of anticipated changes in the economy	1	2	3	4	5	6	7	NA
e. an analysis of the impact of anticipated changes in the future societal issues	1	2	3	4	5	6	7	NA
f. an analysis of the impact of anticipated changes in the future technology	1	2	3	4	5	6	7	NA
g. an analysis of the impact of competitors' strategies	1	2	3	4	5	6	7	NA
h. an analysis of the ability of suppliers to meet our demands	1	2	3	4	5	6	7	NA
i. an analysis of the impact of our product life cycle	1	2	3	4	5	6	7	NA
j. an analysis of the strength of internal functions (human resource, research and development, production, finance, and marketing	1	2	3	4	5	6	7	NA
k. a means for monitoring the strategy implementation over time	1	2	3	4	5	6	7	NA
12.The organization has	**Strongly disagree..... Strongly agree**							
a. designed the quality into the product ,instead of inspecting	1	2	3	4	5	6	7	NA
b. developed goals for key results (customer satisfaction)	1	2	3	4	5	6	7	NA

rather than goals for activities (number of training programs)								
c. done a thorough overall assessment using well established criteria (ISO 9000, Missouri Quality Award)	1	2	3	4	5	6	7	NA
13.To improve the quality of products/ services provided by external sources , this organization has	**Strongly disagree..... Strongly agree**							
a. a formal supplier evaluation system	1	2	3	4	5	6	7	NA
b. an active partnership with suppliers to improve quality , price , and delivery	1	2	3	4	5	6	7	NA
c. constantly evaluated suppliers' quality improvement	1	2	3	4	5	6	7	NA
14.In this organization	**Strongly disagree..... Strongly agree**							
a. financial return is emphasized in setting strategic direction for quality improvement activities	1	2	3	4	5	6	7	NA
b. financial data is used to evaluate potential process improvements impacting quality	1	2	3	4	5	6	7	NA
c. benchmarking practices are targeting on the organization's priorities	1	2	3	4	5	6	7	NA
d. cost of quality is precisely measured	1	2	3	4	5	6	7	NA
e. cost of quality is precisely controlled	1	2	3	4	5	6	7	NA
15.In this organization	**Strongly disagree..... Strongly agree**							
a. the performance appraisals of its organization's members include quality improvement criteria	1	2	3	4	5	6	7	NA
b. quality is used as an assessment criterion for senior management compensation	1	2	3	4	5	6	7	NA
c. people are rewarded for good work	1	2	3	4	5	6	7	NA
d. people receive promotions because they earned them	1	2	3	4	5	6	7	NA
e. people receive coaching and support when things go wrong	1	2	3	4	5	6	7	NA
f. team recognition and incentives for quality improvement efforts are given	1	2	3	4	5	6	7	NA
16.It's common to take quality program implementation into consideration when the organization is doing in performance appraisal at	**Strongly disagree..... Strongly agree**							
a. managerial level	1	2	3	4	5	6	7	NA
b. administrative / clerical personnel level	1	2	3	4	5	6	7	NA
c. production /maintenance / service workers level	1	2	3	4	5	6	7	NA
17.It's common to take quality program implementation into consideration when the organization is rewarding its employees at	**Strongly disagree..... Strongly agree**							
a. managerial level	1	2	3	4	5	6	7	NA
b. administrative /clerical personnel level	1	2	3	4	5	6	7	NA
c. production / maintenance /service workers level	1	2	3	4	5	6	7	NA
18.How comprehensive are your organization's employee training programs	**No program..... All areas**							
(A comprehensive training program should cover *job-related skills, cross function training, problem-solving* such as statistics and data analysis, *customer-supplier relationships*, teamwork and leading meetings)	1	2	3	4	5	6	7	NA

19.In this organization , training programs are	**Strongly disagree..... Strongly agree**							
a. coupled with real-time problem solving	1	2	3	4	5	6	7	NA
b. followed-up to ensure that training programs produce the desired results	1	2	3	4	5	6	7	NA
c. designed to cover basic quality skills -SPC, brainstorming	1	2	3	4	5	6	7	NA
d. designed to include in house	1	2	3	4	5	6	7	NA
e. designed to include external training programs	1	2	3	4	5	6	7	NA
f. designed to include a realistic schedule for replacing outdated training equipment and supplies	1	2	3	4	5	6	7	NA
20.In this organization, employees at all level	**Strongly disagree..... Strongly agree**							
a. have the authority to correct problems when they occur	1	2	3	4	5	6	7	NA
b. are allowed to be creative when they deal with problems at work	1	2	3	4	5	6	7	NA
c. are encouraged to handle job-related problems by themselves	1	2	3	4	5	6	7	NA
d. have opportunity to exchange information with their supervisors	1	2	3	4	5	6	7	NA
e. have the rapid access to the information they need to do a good job	1	2	3	4	5	6	7	NA
f. are invited to participate in setting goals or objectives related to their work	1	2	3	4	5	6	7	NA
21.This organization	**Strongly disagree..... Strongly agree**							
a. has a formal employee suggestion program	1	2	3	4	5	6	7	NA
b. uses team building (techniques to improve group member relationship)	1	2	3	4	5	6	7	NA
c. has fully established quality improvement teams	1	2	3	4	5	6	7	NA
d. responds quickly to employee suggestions and translates them into action	1	2	3	4	5	6	7	NA
e. has made major changes in its system (organizational structure) to facilitate employee empowerment and implement TQM	1	2	3	4	5	6	7	NA
22.The organization has	**Strongly disagree..... Strongly agree**							
a. good and close working relationship and/or partnerships with key suppliers	1	2	3	4	5	6	7	NA
b. used quality in addition to delivery and price to evaluate the performance of its key suppliers	1	2	3	4	5	6	7	NA
c. actions and plans to improve suppliers' abilities to meet quality requirements	1	2	3	4	5	6	7	NA
d. expected suppliers to improve quality continuously	1	2	3	4	5	6	7	NA
23. How effective do you think the communication channels between departments/functions are in this organization (in terms of cycle times?)	**Very ineffective..... Very effective** 1 2 3 4 5 6 7 NA							
24. How often do work delays occur in this organization?	**Very often .....Very uncommon** 1 2 3 4 5 6 7 NA							
25. Process improvement methods (analysis and research)	**Strongly disagree..... Strongly agree**							
a. involve a wide range of possible approaches (process mapping , optimization, experiments)	1	2	3	4	5	6	7	NA

b. involve extensive employees' feedback	1	2	3	4	5	6	7	NA
c. involve extensive customers' feedback	1	2	3	4	5	6	7	NA
26.This organization has	**Strongly disagree..... Strongly agree**							
a. used diagrams or flow charts to highlight potential causes of problems	1	2	3	4	5	6	7	NA
b. used statistical methods to control processes	1	2	3	4	5	6	7	NA
c. analyzed data concerning quality of processes in order to determine whether improvements in quality are needed	1	2	3	4	5	6	7	NA
d. used surveys/interview members to improve processes	1	2	3	4	5	6	7	NA
e. used benchmarking information to improve processes	1	2	3	4	5	6	7	NA
f. used job design techniques to increase flexibility and to motivate employees	1	2	3	4	5	6	7	NA
g. made efforts to update work methods or simplify processes	1	2	3	4	5	6	7	NA
h. designed its products/services for ease of production in addition to insuring that the users' requirements are met	1	2	3	4	5	6	7	NA
i. designed its products/services for ease of delivery in addition to insuring that the users' requirements are met	1	2	3	4	5	6	7	NA
j. involved the customers in the quality improvement efforts	1	2	3	4	5	6	7	NA
k. involved the suppliers in the quality improvement efforts	1	2	3	4	5	6	7	NA
l. made efforts to salvage or reuse excess supplies and material whenever possible	1	2	3	4	5	6	7	NA
27.The organization has used the graphs and tables including appropriate comparative data to post the current trends in key quality and operational measures and/or indicators of	**Strongly disagree..... Strongly agree**							
a. product and service quality results	1	2	3	4	5	6	7	NA
b. company operational and financial results	1	2	3	4	5	6	7	NA
c. supplier performance results	1	2	3	4	5	6	7	NA
28. In this organization	**Strongly disagree..... Strongly agree**							
a. managers at all levels have the authority to try a promising new approach	1	2	3	4	5	6	7	NA
b. a promising new approach is likely to be approved quickly for a trial	1	2	3	4	5	6	7	NA
c. creative thinking about improvement of quality is rewarded	1	2	3	4	5	6	7	NA
d. managers and employees at all level make continuous efforts to improve work processes	1	2	3	4	5	6	7	NA
29. In order to determine what our customers think about our products/service/work, this organization	**Strongly disagree..... Strongly agree**							
a. conducts surveys on a regular basis	1	2	3	4	5	6	7	NA
b. conducts surveys not only on current customers, but on potential and competitors' customers as well	1	2	3	4	5	6	7	NA
c. asks employees who have contact with its customers	1	2	3	4	5	6	7	NA
d. has measurement scales for customer satisfaction and dissatisfaction (complaints, refund, recalls, returns, repeat services, incomplete orders)	1	2	3	4	5	6	7	NA
30.This organization has	**Strongly disagree..... Strongly agree**							
a. created or selected customer groups and market segments based upon customer characteristics or market-related information	1	2	3	4	5	6	7	NA
b. a clear internal definition of quality	1	2	3	4	5	6	7	NA

c. an agreement with each customer group as to what constitutes quality	1	2	3	4	5	6	7	NA
31. In this organization	**Strongly disagree..... Strongly agree**							
a. customer-contact employees are empowered to make on-the-spot decisions to act in the interest of customers without getting prior approval	1	2	3	4	5	6	7	NA
b. customer-contact employees have received special training in problem handling and customer retention	1	2	3	4	5	6	7	NA
c. a customer complaint/suggestion program is in place and provides feedback to appropriate areas	1	2	3	4	5	6	7	NA
d. customer complaints and problems are resolved promptly and effectively	1	2	3	4	5	6	7	NA
32. The organization's customers	**Strongly disagree..... Strongly agree**							
a. have confidence that the company cares for what they think	1	2	3	4	5	6	7	NA
b. would not change their loyalty to go elsewhere even if it were possible	1	2	3	4	5	6	7	NA
c. don't complain very often	1	2	3	4	5	6	7	NA
d. are satisfied with the quality of our work	1	2	3	4	5	6	7	NA

Organizational Performance Level Measurement
COMPANY PROFILE

*For all questions please type your answers on the dotted lines **and** check the appropriate boxes*

1. Industry type: Public ☐ Private ☐

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2. Number of employees: .....

Fewer than 100 ☐ 100-249 ☐ 250-499 ☐ 500-999 ☐ 1000 or more ☐

---

3. Square footage of plant: .....SQFT

0-49,999 ☐ 50,0000- 99,999 ☐ 100,000-249,999 ☐ 250,000-499,999 ☐

500,000 -1,000,000 ☐

---

4. Years since plant startup: .....years

0-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ >20 years ☐

---

5. Product type: .....

Discrete ☐ Process ☐ Both ☐

---

6. Industry Type: .....

Paper & Allied products ☐ Furniture & Fixtures ☐ Printing and Publishing ☐

Chemicals & Allied Products ☐ Rubber and Miscellaneous Plastic Products ☐

Fabricated Metal Products ☐ Industry Machinery & Equipment ☐

Electronic & Other Electrical Equipment ☐ Transportation Equipment ☐

Instruments & Related Products ☐ Other Manufacturing Industries ☐.....

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7. Number of years since the first ISO 9000 certification? Certification date.....

0-3 years ☐ 4-7 years ☐ 8-10 years ☐ 11-15 years ☐ > 15 years ☐

---

9. Has plant received QS 9000 certification? Yes ☐ No ☐ Date:.....

---

10. Has plant received ISO 14000 certification? Yes ☐ No ☐ Date:.....

---

11. Is plant currently profitable? Yes ☐ No ☐

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12. Do you wish to receive a final report on your benchmark results? Yes ☐ No ☐

QUALITY

*For all questions please type your answers on the dotted lines **and** check the appropriate boxes*

1. People dedicated to quality as a percentage of total workforce: (%)
.....

☐ 0-10% ☐ 11-24% ☐ 25-49% ☐ 50-74% ☐ 75-100%

2. Quality techniques extensively implemented (mark all those apply):

☐ Six Sigma ☐ Quality function deployment (QFD) ☐ Poka-yoke (mistake-proofing)

☐ others..... ☐ Failure mode effect analysis (FMEA)

☐ Design of experiments ☐ Employee problem-solving teams ☐ plan/do/check/verify

☐ Advanced product quality planning (APQP) ☐ Manual / Computerized SPC ☐ 5S

3. Average Cpk value - across all processes where Cpk measurements are applicable:

☐ <1.0 ☐ 1.0-1.24 ☐ 1.25-1.32 ☐ 1.33-1.66 ☐ >1,66

4. In-plant defect rate (fallout rate) on manufactured components: (PPM)
.....
[Total number of defective parts (manufactured) / total number of manufactured parts] x 1,000,000

5. In-plant defect rate (fallout rate) on purchased components: (PPM).....
[Total number of defective purchased parts / total number of manufactured parts] x 1,000,000

6. Finished product reject / rework rate: (PPM).....
[Total number of rejected & reworked finished product / total number of finished product produced] x 1,000,000

7. Customer complaint rate on shipped products: (PPM) .....
[Total number of parts found defective by customer / total number of shipped parts to customer] x 1,000,000

8. Average response rate to customer complaints: (in days)..... days

☐ <1 day ☐ 1-3 days ☐ 4-6 days ☐ 7-10 days ☐ >10 days

9. How often customer satisfaction surveys are performed:.....

☐ once a year ☐ semiannually ☐ every two years ☐ every three years ☐ other.....

COST

*For all questions please type your answers on the dotted lines **and** check the appropriate boxes*

10. Scrap/rework costs as a percent of annual sales: (%).....

<1% ☐ 1-1.9% ☐ 2-2.9% ☐ 3-3.9% ☐ 4.0-4.9% ☐ >5.0% ☐

11. Warranty costs as a percent of annual sales: (%).....

<0.5% ☐ 0.5-0.9% ☐ 1-1.9% ☐ 2.0-2.9% ☐ 3.0-4.9% ☐ >5.0% ☐

12. Logistics costs (including transportation and inventory cost) as a percentage of annual sales: (%).....

<1% ☐ 1-1.9% ☐ 2-2.9% ☐ 3-3.9% ☐ 4.0-4.9% ☐ >5.0% ☐

13. Cost spent on quality activities (inspection, audit, calibration) as a percentage of annual sales: (%).....

<1% ☐ 1-1.9% ☐ 2-2.9% ☐ 3-3.9% ☐ 4.0-4.9% ☐ >5.0% ☐

14. Annual labor costs budgeted to training: (%).....

0-2% ☐ 3-5% ☐ 6-8% ☐ 9-11% ☐ 12-14% ☐ >15% ☐

15. Maintenance cost as a percentage of annual sales: (%).....

<1% ☐ 1-1.9% ☐ 2-2.9% ☐ 3-3.9% ☐ 4.0-4.9% ☐ > 5.0% ☐

16. Total annual research and development cost as a percentage of annual sales: (%) .....

0-2% ☐ 3-5% ☐ 6-8% ☐ 9-11% ☐ 12-14% ☐ >15% ☐

17. Investment in information systems and technology (include hardware, software, training, and support) as percentage of annual sales: (%).....

<1.0% ☐ 1.0-1.9% ☐ 2.0-2.9% ☐ 3.0-3.9% ☐ 4.0-4.9%☐ > 5.0% ☐

18. Investment in production technology and equipment as a percentage of annual sales: (%)....

<1.0% ☐ 1.0-1.9% ☐ 2.0-2.9% ☐ 3.0-3.9% ☐ 4.0-4.9%☐ > 5.0% ☐

19. Approximate 3-year manufacturing cost change per unit of product shipped: (%).....

Decreased more than 20% ☐ Decreased 11-20 % ☐ Decreased 1-10 % ☐

Increased 0-10% ☐ Increased 11-20% ☐ Increased more than 20% ☐

20. Percent change of customer price of typical product (highest volume) over the past 3 years: (%).....

Decreased more than 20 % ☐ Decreased 11-20 % ☐ Decreased 1-10 % ☐

Increased 0-10% ☐ Increased 11-20% ☐ Increased more than 20% ☐

DELIVERY

*For all questions please type your answers on the dotted lines **and** check the appropriate boxes*

21. Extensive use of following techniques: (Mark all those apply)

☐ Advanced planning and scheduling systems (APS) ☐ EDI links to customers/suppliers

☐ Forecast/demand-management software ☐ Online order-entry/product-configuration

☐ Transportation management systems ☐ Others.....

22. What is the manufacturing cycle time for a typical product? (Hours) the time it takes for product to move through the entire value system: .....

23. What percentage of supplier orders delivered on-time? (by the request date, +/-1day: on time) %.....

☐ <90% ☐ 90.0-92.4% ☐ 92.5-94.9% ☐ 95.9-97.4% ☐ 97.5-100%

24. What is the current standard order-to-shipment lead-time? (Days: 1 day=24 hours.....hrs

25. What is the current on-time delivery rate for total orders delivered (%)? (by the request date, +/-1day: on time).....

☐ <90% ☐ 90.0-92.4% ☐ 92.5-94.9% ☐ 95.9-97.4% ☐ 97.5-100%

26. Within regular production, what is plant's longest/ shortest changeover time? (Hours)

Longest ..... Shortest.....

27. What percentage of raw material inventory is safety stock? (%).....

☐ <1% ☐ 2-4% ☐ 5-7 % ☐ 8-10% ☐ >10%

28. What percentage of finished good inventory is safety stock? (%).....

☐ <1% ☐ 2-4% ☐ 5-7 % ☐ 8-10% ☐ >10%

29. Percentage of new products launched to market on-time? (%).....

☐ <90% ☐ 90.0-92.4% ☐ 92.5-94.9% ☐ 95.9-97.4% ☐ 97.5-100

30. Average machine availability rate as a percentage of scheduled uptime: (%).....

☐ <90% ☐ 90.0-92.4% ☐ 92.5-94.9% ☐ 95.9-97.4% ☐ 97.5-100

31. For all production lines, what is mean time between equipment failure? (Hours).....

☐ <500 hours ☐ 500-699 hours ☐ 700-899 hours ☐ 900-1099 hours ☐ >1100 hours

32. Over the last two years, how significantly has your company expressed improvement in the following areas? (Please write the appropriate % in the corresponding box)

	No Improvement 0%	Little Improvement 0-25%	Some Improvement 25-50%	Much Improvement 50-75%	Great Improvement 75-100%
a. In-plant defect rate on manufactured components					
b. In-plant defect rate on purchased components					
c. Finished product reject/ rework rate					
d. Reduced customer complaint rate					
e. Customer complaint response rate					
f. Process capabilities -cpk					
g. Reduced warranty cost as % of sales					
h. Reduced logistics cost as % of sales					
i. Reduced maintenance cost as % sales					
j. Production cycle time reduction					
j. Reduced change over time					
k. On time delivery to customer					
l. Reduced lead time to customer					
m. New product launch on-time to market					
n. Increased machine availability rate					

VITA

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