Assessing the Impact of Quality Management Systems on Business Performance

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Abstract

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Manjot Singh Bhatia

In the past few decades, a number of organizations have implemented Quality Management Systems (QMS) to create a culture of continuous quality improvement and improve business performance. Various QMS implemented in organizations are ISO 9000 Standards, Total Quality Management, AS Aerospace Standards, and many more. These standards cover aspects such as management leadership, process management, teamwork, quality improvement, and supplier and customer relations. The implementation of QMS is ultimately expected to improve overall business performance.

In this thesis, we study the overall impact of implementation of QMS on various business performance factors. These performance factors include information quality, operating performance, design performance, environmental performance, product and service quality, supplier and customer relationships and competitive priorities. To study the impact of implementation of QMS on these business performance factors, we proposed a hypothesis model linking these performance factors, showing how improvement in one factor brings improvement in other factor. In this regard, a questionnaire was prepared related to implementation of QMS on business performance factors, and a survey study was conducted with professionals involved in quality management and engineering to collect their

views on implementation of QMS. The collected data was analyzed with the help of statistical techniques such as Factor analysis, Descriptive statistics and Regression analysis, to study the proposed hypothesized relationships in the model.

The results of our study show that organizations often implement QMS as a catalyst for change and use them in daily practice. Most of the proposed hypotheses are found to have significant positive relationship, whereas not enough significance is found between information quality and environmental performance, between design performance and product quality, and between environmental performance and product quality. It is recommended as future work to collect more data to statistically validate the relationships between design performance and product quality and between environmental performance and product quality.

Keywords: QMS, Information Quality, Product Quality, Service Quality, Business performance.

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List of Acronyms

QMS: Quality Management Systems

TQM: Total Quality Management

ISO: International Organization for Standardization

SCM: Supply Chain Management

JIT: Just in Time

SME: Small Manufacturing Enterprises

SCRQ: Supply Chain Relationship Quality

QM: Quality Management

AS: Aerospace Standards

KMO: Kaiser-Meyer-Olkin

R: Removed from analysis

Chapter 1: Introduction

1.1 Background

With increasing competition and globalization, supply chain quality management concept is on the forefront of the industry today. It requires coordinating with suppliers and customers, rather than treating them as adversaries, to make the flow of materials smoother from supplier to end-customer. It encompasses optimizing various concepts such as reducing product lead times, promoting just in time concepts, improving product quality etc. The organizations need to control not only costs but also quality in the supply chain to be successful in their businesses (Radovilsky et al. 2011). Successful supply chain management vastly depends on how the quality is being managed throughout the system. Hence, it is not false to say that quality management is necessary to be successful in today's competitive world.

Various types of quality need to be managed within and outside an organization, in a supply chain. This includes information quality, product quality, service quality etc. This has resulted in the implementation of Quality Management systems in a number of organizations around the world. Implementation of QMS is being used as one of the most effective tools by organizations to control and improve quality, and hence increase business competitiveness (Priede, 2012). Various Quality Management Systems are being implemented by organizations, the most famous being standards given by International Organization for

Standardization (ISO) and Total Quality Management (TQM) tools. Some other quality management systems being implemented are AS standards, which are specifically implemented in Aerospace industry, TS standards implemented in automotive industry, and many more. The bottom-line for the organizations is that they want improved business performance as a result of implementation of Quality Management Systems, through improvement in one or more intermediate factors, such as information quality, operating performance, service quality etc.

This thesis investigates the impact of implementation of Quality Management Systems on Business Performance, through improvement in various intermediate factors.

1.2 Research Problem

In the past few decades, many organizations have implemented QMS, either due to external reasons, such as customer pressure or internal reasons such as to improve customer service, base for quality improvement etc. (Van Der Wiele et al., 1997). Some organizations have also implemented QMS as a catalyst for change, such as to change organizational culture, have a starting point for quality improvement etc. The practices of QMS are expected to bring improvement in Business Performance by improving information quality, operating performance, product quality, service quality etc. Kaynak (2003) identifies positive relationship between various TQM Practices and examines their direct and indirect effect on quality performance, financial & market performance, through a proposed hypothesis model. Most of the studies have in fact identified relationship between various Quality Management constructs and impact of each on the performance measures. The literature lacks in the research of overall impact of QMS on business performance, through improvement in other factors and studying overall impact of implementation of QMS on various performance factors.

The aim of the thesis is to study effect of implementation of QMS on business performance factors. The following research problems are addressed:

1. Study whether QMS are implemented as a catalyst to bring a change and whether organizations use QMS in daily practice.
2. Study the impact of implementation of QMS on business performance factors, by testing proposed hypotheses. Various business performance factors such as information quality, design performance, operating performance, environmental performance, supplier relationships, customer relationships, product quality, service quality and competitive priorities are considered in a single model, which is lacking in research literature. These factors are considered as they all are expected to bring about improvement in business performance, with implementation of QMS.

1.3 Thesis Outline

The rest of the thesis is as follows: Chapter 2 discusses the previous research studies in the area of implementation of QMS. Chapter 3 discusses solution approach to our research problem, and development of research hypotheses.

Chapter 4 presents and discusses the results of the survey study. Finally, the thesis concludes with Chapter 5, which summarizes the conclusions.

Chapter 2: Literature Review

The following chapter reviews literature and research studies associated with the implementation effects of Quality Management Systems. Various research studies have been done over the past few decades to study the impact of implementation of QMS factors on improvement in quality, performance factors and business performance of organizations. This chapter summarizes the same.

2.1 Implementation of QMS Practices

Saraph et al. (1989) identified eight critical factors of quality, based upon an empirical study, by collecting data from general managers and quality managers. The factors identified were Management Leadership, Role of the Quality department, Training, Product / Service design, Supplier Quality Management, Process Management, Quality Data and Reporting and Employee Relations. These factors can be used by management of an organization to assess the quality improvement in a particular area. Also, the author found strong correlation between factors of quality management and quality performance measure. Black et al. (1996) identified ten critical TQM factors. Customer satisfaction orientation, teamwork structures and communication of improvement information were identified as new factors.

Kim et al. (2012) did a study on ISO 9000 certified manufacturing and service firms and found positive relationship between QM Practices and innovation

(Product, Process and Administrative). QM Practices result in innovation through process management. Also, QM practices were found to be related to each other, directly or indirectly. An empirical analysis of QM Practices in Japanese manufacturing industries shows that implementation of QMS strongly supports quality and competitive priorities. Further, quality practices significantly depend on each other and support each other (Anh et al., 2006). Tari et al. (2007) studied relationship between TQM constructs and Quality outcomes on 106 ISO 9000 certified Spanish manufacturing and service firms. The study finds that leadership plays a critical role in TQM. Leaders define targets and create relationships with suppliers and customers etc. These practices affect process management and help in continuous improvement which further directly impact quality outcomes. The above discussed researches further call to find if QM practices really brought any improvement in business, which is the bottom line for management.

Molina et al. (2007) empirically studied and found positive relationship between quality management practices (supplier cooperation, customer cooperation, teamwork, autonomy and process control) and firm performance through internal, supplier and customer knowledge transfers. Implementation of QM practices increases sharing of knowledge, information, techniques etc. among team members and establishes climate of cooperation with suppliers and customers, which further increases firm's performance. Mann et al. (1994) concluded that various quality activities and particularly TQM indeed benefit business performance.

Samson et al. (1999) found in an empirical study in Australia and New Zealand manufacturing industry that improved leadership, human resources management and customer focus more likely improve firm's performance than strategic quality planning, process management and information and analysis. The research suffers from a limitation of low factor analysis scores of measurement variables. Also, it calls to take into account the factors between QMS practices and performance.

Kaynak (2003) studied the direct and indirect effects among various TQM constructs and effect of these on three levels of performance: Inventory Management performance, Quality performance and financial and market performance. He found positive relationship between TQM constructs and these performance measures. Supplier quality management, product/service design and process management had direct effects on operating performance (inventory management and quality performance). Management leadership, training, employee relations, and quality data and reporting affect operating performance indirectly through supplier quality management, product/service design and process management. TQM practices had positive indirect effect on financial and market performance through operating performance. This research, although takes many factors into account, fails to account for information quality, customer relationships and environment performance. Kaynak et al. (2008) included customer focus as QM practice. In another study by Kaynak et al. (2005), high performing high technology firms were found to have implemented QM practices to a greater extent than low performing high technology firms, which shows that QM practices can definitely add advantage.

Fynes et al. (2001) concluded design quality to be pivotal in quality performance, and that it has significant impact on Conformance quality, product cost, external quality – in – use etc. Also, the study found that low product cost with high levels of quality lead to improved customer satisfaction. This study fails to consider that design quality is not the only factor that impacts quality performance. In fact, quality performance can highly depend on operating performance.

2.2 Reasons for the Implementation of ISO Standards

A survey study carried out by Van Der Wiele et al. (1997) in Australian ISO 9000 certified SME's found that ISO 9000 certification should be implemented as a means for internal reasons such as to improve customer service, improve efficiency etc. rather than for external reasons, to perceive more benefits. The study reveals that ISO 9000 certification can help gain access to markets but it does not assure success.

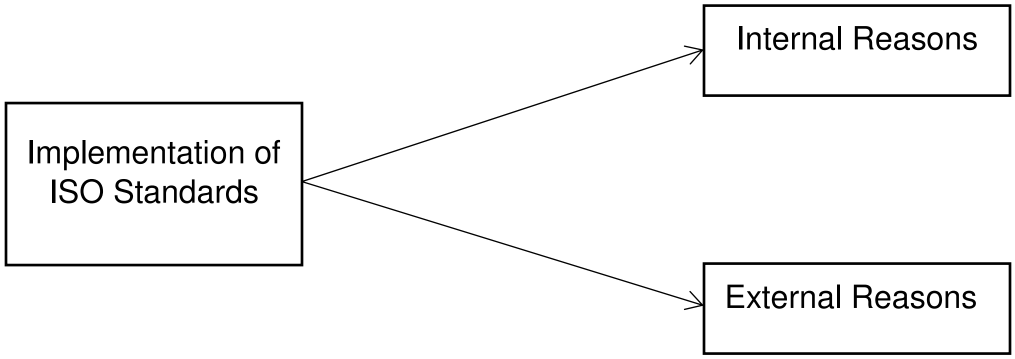

Fig 2.1: Reasons for the implementation of ISO Standards

In another study carried by Gotzamani et al. (2002) in Greek ISO 9000 certified organizations, they found that organizations implemented ISO mainly for internal reasons such as quality improvement and less in response to customer demand and pressure. Moreover, standards contributed higher to organizations implementing ISO 9000 for quality and performance improvement of their operations. Magd et al. (2012) carried a study in UAE organizations and found that organizations implement ISO standards both for internal and external reasons. Further, internal reasons were found to be more dominant than external reasons.

Most studies have surveyed the reasons for implementation of QMS; the literature lacks in the findings whether QMS are implemented as a catalyst to bring a change, as a separate factor and whether QMS are really used in daily practice after implementation. It is expected that organizations can reap maximum benefits, if they really use QMS in daily practice.

2.3 Implementation of ISO 9000 Standards and Performance

A number of research studies have been done to study the impact of ISO 9000 standards on performance of an organization. Casadesús et al. (2000) found that 65 percent of the companies benefitted internally and externally from ISO standards and only 6 percent showed very less benefits. Koc (2007) found that ISO 9000 implementation makes significant difference on many manufacturing parameters and competitive parameters. The study suggests that improvement in manufacturing parameters provides better value to customers which in turn lead to improvement in firm's performance.

Terziovski et al. (2003) found a positive relationship between quality culture of ISO certified organizations and benefits from certification, which shows the motive for adopting the certification as significant predictor of benefits from ISO 9000. Customer focus was found to contribute most to business performance. This agrees with the empirical study by Kannan and Tan (2007), which suggests that firms should carefully assess customer expectations. Singh (2008) did empirical study in 418 Australian ISO 9000 registered manufacturing plants. Singh supports that senior management is responsible for establishing the organizational process, by which an organization can maintain stable processes, and generate performance related outcomes.

Fig 2.2: Implementation of ISO 9000 Standards and Performance

Another empirical study done by Naveh et al. (2005), found that implementation of ISO 9000 standards indeed led to improvements in operating performance, however their effects on business performance was limited. Piskar (2007) study on Slovenian companies clearly reveals that implementation of ISO 9000 standards results in better satisfying the customer, but does not directly affects business performance. These results call for study of other performance factors which indeed mediate effect between implementation of QMS and business performance of an organization.

Lo et al. (2009) revealed that ISO 9000 standards implementation in US manufacturing firms led to decrease in number of inventory days and significant improvement in overall operating cycle time. The study shows that ISO standards indeed help in improving material and cash flows in supply chain.

Adams (1999) did not found ISO to be statistically significant related to firm's profitability in the New Zealand manufacturing sector. The author cites reason for this as that managers being more focused on conforming with procedures related to standards, rather than taking on improvement activities, which actually help to increase profits. Huarng et al. (1999) concluded that process and motivation affects the ISO 9000 standards performance. These researches failed to report whether organizations implemented QMS for internal reasons and whether organizations really used QMS after implementation.

Buttle (1997) found in an empirical study that companies implement ISO 9000 standards for both operational and marketing benefits. The author further found positive relationships between satisfaction and profitability, process improvement and marketing benefits (Benefits after getting ISO certification).

Poksinska et al. (2002) carried a study on Swedish organizations and found that organizations implement ISO standards mainly to improve corporate image and quality processes. Moreover, companies that implement ISO standards focusing on quality improvement benefits achieve higher overall benefits than organizations that implement ISO standards merely for external reasons.

2.4 Implementation of ISO 14000 Standards

A study done by Poksinska et al. (2003) in Swedish companies concludes that companies merely implemented ISO 14000 environmental standards for external benefits, rather than really committing themselves to environment protection. The study also found ISO 9000 being more important to companies than ISO 14000, obviously, because ISO 9000 contains more number of sub - standards than ISO 14000.

Zeng et al. (2005) carried similar study of implementation of ISO 14000 standards on selected Chinese industries. The results reveal that much motivation of companies was just to enter international market, as in many cases, although other benefits were also found. Organizations should implement ISO 14000 not only to enter market, but should understand that these can improve environment, if put in daily use and ultimately help improve product quality, which these research studies fail to study.

2.5 ISO and Integration of other Quality Management Practices

Empirical study done by Gotzamani et al. (2001) in Greek industry reveals that ISO 9000 standards indeed result in improvement in TQM areas. The standard helps to improve quality culture and offers significant benefits to certified companies. Zakuan et al. (2012) carried a study in Thailand automotive industry and found that implementing ISO/TS 16949 certification did not impact the relationship between TQM implementation and organization performance measures, suggesting further research in this area. Zakuan et al. (2009) also showed similar results. These studies indeed show that ISO standards in coordination with TQM and other QMS, may or may not result in improved performance. This may actually vary from region to region, and from organization to organization.

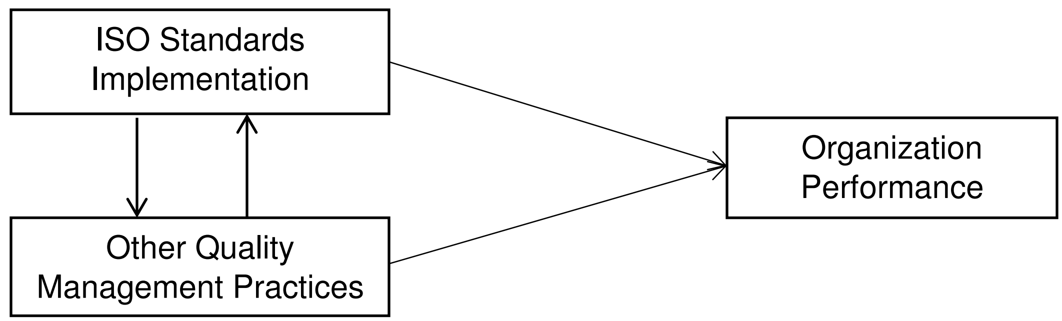

Fig 2.3: ISO Standards, other QM Practices and Organization Performance

Martínez - Costa et al. (2008) studied implementation of TQM Practices and ISO 9000 Standards together, rather than separately, as done in many research studies. It was found that internal motivation to implement ISO 9000 standards resulted in high performance, whereas external motivation did not. Also, implementation of TQM resulted in both improved internal and external results.

Rahman (2001) carried out a study in SMEs in Western Australia and found no significant differences of impact of QM factors on organizational performance, except process control, for firms with and without ISO 9000 certification.

Quazi et al (2004) carried out a survey to study the impact of ISO 9000 standards on training and development activities in organizations in Singapore. The study identified improvements in training and HRD activities as a result of implementation of ISO 9000 Standards.

Douglas et al. (2003) carried a study of over 100 quality managers in UK industry and found that professionals were quite content with impact of ISO 9000 standards, and it was considered as first step to TQM by many. Equally, ISO 9000 standards did not meet many of the expectations, calling more research in this area.

Zhang (2000) studied and found that Quality Management methods have positive effects on product quality. An interesting finding of the study was that ISO 9000 had a much lower impact on performance factors than TQM. This calls for more research in this area. Further, TQM leads to improvement in strategic business performance, process quality, supplier quality management, customer focus etc.

2.6 Supply Chain Quality Management

A study carried in North America and Europe found out that although SCM, TQM & JIT are different concepts, many elements of these three concepts are common and if implemented together, they can add value to respond to competitive pressures. The study further finds out that besides quality, supply chain relationships can significantly impact a firm’s performance (Kannan and Tan, 2005). Research done by Kannan and Tan (2007) on operational quality in a supply chain suggests that not only internally focused efforts on quality improvement, but externally focused efforts with suppliers and customers effect product and service quality. Customer service was found to have a significant impact on product and service quality, which suggests that firms should carefully assess customer expectations.

Lin et al. (2005) concluded from a survey study that organizational performance can be optimized when an organization considers its suppliers as members of value chain. Moreover, the author found that QM practices indirectly affect business performance, where supplier participation acts as a mediator.

Sila et al. (2006) carried out an empirical analysis to study state of supply chain quality implementation in US manufacturing firms. The study found that although companies involved their major customers in quality initiatives, they did not involve major suppliers.

Fynes et al. (2005) found positive effect of supply chain relationship quality (SCRQ) on design quality, which in turn had positive effect on conformance quality and customer satisfaction. Another research conducted by Fynes et al. (2005) in electronics manufacturing firms in Republic of Ireland indicates positive impact of SCRQ on supply chain performance. Constructs measuring supply chain relationship quality were based on cooperation, adaptation, trust and communication with customer. The study had the limitation that it ignored the view point of customer altogether, which is also important in supply chain. These studies suggest considering both customer relationships and supplier relationships, and viewpoints of both suppliers and customers, when studying the effect of relationships on performance.

Stanley et al. (2001) found positive relationship between implementation of supplier relationships and buyer's ability to deliver service quality to internal customers. Also, the study found that performance level of manufacturer played an important role in providing service quality to customers. Tan et al. (1999) suggested that due to growing competition, firms should go beyond improving just product quality. Suppliers, manufacturers and customers need to integrate with each other to achieve growth objectives. Further, he finds that supply chain needs to be managed effectively, and firms should pursue new markets, technologies and improve cost and delivery performances, to successfully survive in this global competition.

Lai et al. (2005) found that suppliers regard stable relationships with buyers as positively related to their commitment to quality, and this relationship is further strengthened when supplier's perception of certainty of supply with buyer is greater. Further, Prajogo et al. (2012) found positive relationships between supplier management practices and operational performance measures. The study found positive relationship between supplier assessment and quality performance. Further, strategic long-term relationship and logistics integration were found to be positively related to delivery, flexibility and cost performance.

Srinivasan et al. (2011) demonstrated positive relationship between partnership quality and supply chain performance. This relationship is further strengthened in the presence of high demand side risk. Close partnerships can lead to information sharing among supply chain partners and can help mitigate risks.

Li et al. (2006) found that trust in supply chain partners and shared vision between them had a positive impact on information quality and information sharing. The research lacks to further find how information quality and information sharing can impact other performance factors, but this lays a good foundation for our study. Table 2.1 summarizes the QM and performance constructs considered by authors in various research studies:

Table 2.1: Literature Review: QM and Performance Constructs

Research Study	QM and Performance Constructs
Molina et al. (2007)	Supplier Cooperation, Customer Cooperation, Teamwork, Autonomy, Process Control, Performance
Kannan et al. (2005)	Just in Time, Quality Management, Supply chain management, Business Performance
Singh (2008)	Management policies, plans & actions, Consistent quality outputs, Business Performance, Satisfied customers, Reliable suppliers, Focus on customers
Park et al. (2001)	Process management, Supplier Management, Information Management, Employee Satisfaction
Kaynak (2003)	Supplier Quality management, Product / Service Design, Process Management, Quality Performance, Quality data & reporting, Employee relations, Inventory management performance, Financial & market performance, Training.
Naveh et al. (2005)	Installation and usage of ISO 9000 Standards, Operating Performance, Business Performance

Kim et al. (2012)	Supplier Quality management, Process management, Product / Service Design, Quality Data & Reporting, Customer Relations, Training, Management Leadership
Samson et al. (1999)	Leadership, People Management, Customer Focus, Strategic Planning, Information and Analysis, Process Management
Tari et al. (2007)	Quality tools and techniques, Quality planning, Customer focus, Supplier management, Process management, Continuous improvement, Quality outcomes
Rahman (2001)	Information & Analysis, Processes, Products & Services, People, Customer Focus, Organizational Performance
Saraph et al. (1989)	Process Management, Quality Data & Reporting, Supplier quality management, Product / Service design, The role of management leadership and quality policy, Role of the quality department
Fynes et al. (2005)	Cooperation, Trust, Supply chain relationship quality, Design Quality, Conformance Quality, Customer Satisfaction
Tan et al. (1999)	TQM Practices, Supply Chain Management Practices, Customer relations practices, Performance
Kannan et al. (2007)	Customer input, Supplier quality, Design quality, JIT quality, Process integrity, Product quality, Customer service
Fynes et al (2001)	Customer Involvement, Feedback, New Product Quality, Process control, Process management, Quality Leadership, Supplier Involvement, Teamwork, Business Performance
Koc (2007)	Manufacturing parameters, Competitive priorities, Firm performance
Zhang (2000)	Strategic business performance, Processes, Supplier quality management, Customer focus, People

Anh et al. (2006)	Customer oriented, Supplier relationship, Process control, Product design process, Cleanliness and organization, Perceived quality market outcome, Competitive Performance, Top management support quality.
Zakuan et al. (2012)	Quality leadership, customer focus and satisfaction, quality information & analysis, quality results, business result
Martínez-Costa et al. (2008)	Leadership, Process control, Process management, New products design, Suppliers, Customers
Sousa et al. (2002)	Quality Management Practice, Internal Process Quality, Operational Performance, Business Performance, Product Quality Performance
Reed et al. (2005)	Leadership & Commitment, Training & Education, Culture
Prajogo et al. (2012)	Quality, Delivery, Flexibility, Supplier assessment, Strategic long - term relationship
Black et al. (1996)	Corporate Quality culture, Operational Quality Planning, Supplier Partnerships, People and Customer Management, Customer Satisfaction Orientation, Quality Improvement Measurement Systems
Li et al. (2006)	Information sharing and information quality, Inter – Organizational Relationships, Environmental Uncertainty
Flynn et al. (1994)	Top Management Support, Quality information, Process Management, Product Design, Supplier involvement, Customer involvement
Lin et al. (2005)	QM Practices, Supplier participation, Supplier selection, Organizational performance
Koçoğlu et al. (2011)	Supply chain integration, Information sharing, Supply Chain Performance

Radovilsky et al. (2011)	Service competency, Customer support, Delivery, Product Quality, Service Availability
Kuei et al. (2001)	Top management leadership, Training, Product Design, Supplier quality management, Quality data reporting, Supplier selection, Customer relations, Process management
Tan et al. (2002)	Supply chain management practices, Supplier evaluation practices

From table 2.1, we can conclude that most of the authors have considered some specific elements of QMS and assessed their individual or collective impact on business performance or some other performance measure. Many of the authors have also done research on impact of implementation of TQM or ISO standards on business performance. The research literature lacks in consideration of many other performance factors that are affected by the implementation of QMS such as information quality, design performance, operating performance, environmental performance, supplier relationships, in a single model. Table 2.2 summarizes the solution approaches used by some of the authors in various research studies related to assessing the impact of QMS on business performance.

Table 2.2: solution approaches used by some of the authors in Research studies

Research Study	**Solution Approach**
Molina et al. (2007)	SEM, Factor Analysis
Samson et al. (1999)	Factor Analysis, Regression analysis
Park et al. (2001)	Factor Analysis, Regression analysis

Singh (2008)	Descriptive statistics, SEM
Kaynak (2003)	Descriptive statistics, SEM
Kim et al. (2012)	Factor Analysis, SEM
Terziovski et al. (2003)	Factor Analysis, Regression analysis
Martínez-Costa et al. (2008)	Factor Analysis, ANOVA
Rahman (2001)	Factor Analysis, t-test
Fynes et al. (2005)	Factor Analysis, SEM
Tan et al. (1999)	Factor Analysis, Regression analysis
Kannan et al. (2007)	Factor Analysis, Regression analysis
Fynes et al. (2001)	Path Analysis
Koc (2007)	t-test
Huarng et al.(1999)	Factor Analysis, Regression analysis, Descriptive statistics
Sukati et al. (2012)	Factor Analysis, Regression analysis
Carlsson et al. (1996)	Descriptive statistics
Forker (1997)	Regression analysis
Fynes et al. (2005)	Factor Analysis, t-test
Li et al. (2006)	Descriptive statistics, Regression analysis

From table 2.2, it is evident that most of the authors have used factor analysis approach in their studies. Factor analysis is a very common and necessary analysis technique for any type of survey study. The other analyses commonly used are descriptive statistics, Regression analysis and SEM. Descriptive statistics includes calculating mean, standard deviation, correlation values. This is also necessary to analyze any data. Regression analysis and SEM are commonly used for the purpose of hypothesis testing. Both these approaches have been found to be equally used in research studies.

2.7 Research Gaps

The following section summarizes the research gaps and future works in some of the previous research studies on implementation of Quality Management Systems:

1. Previous research studies in the implementation of QMS have focused mostly on the reasons for implementation of QMS, whether external or internal, and studies have failed to consider whether organizations actually implement QMS as a catalyst for change or use QMS in daily practice. To reap maximum benefits, it is not necessary for organizations just to implement QMS, but QMS should be put into daily use. Previous research literature has failed to consider this point.

2. Previous research literature, although being extensive in studying impact of implementation of QMS on some performance factors, fails to consider many other performance factors that are actually affected by the implementation of QMS such as design performance, operating performance, environmental performance, supplier relationships, in a single model.

3. Many studies on the impact of implementation of QMS, fail to consider business performance factor into account, which is the ultimate and bottom line factor for management of any organization these days.

4. Further, the research literature fails to consider all the major business performance factors such as product quality, service quality etc. in one model. Every study lacks one or other performance factors.

Chapter 3: Solution Approach

In previous chapter, comprehensive literature review was done to study how implementation of QMS affects different performance factors, and ultimately business performance. This chapter gives an insight into the solution approach and techniques used to address our research problem. The chapter discusses development of research hypotheses, survey study to collect data and data analysis approach.

3.1 Development of Research Hypotheses

To study the impact of implementation of QMS on business performance factors, we proposed a research hypothesis model. The research model gives the impact of implementation of QMS on business performance, through improvement in mediator factors such as information quality, operating performance, design performance, environmental performance, supplier and customer relationships, product and service quality, competitive priorities and business performance. The proposed research model is shown in fig. 3.1. In accordance with proposed hypothesized research model, a number of hypotheses were proposed. Next, we discuss the theory behind proposing these hypotheses.

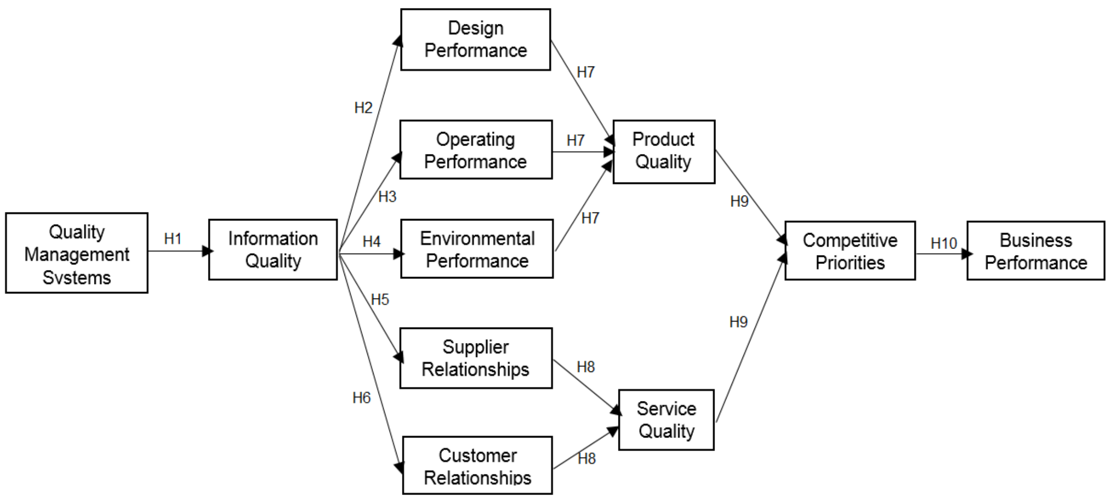

Fig 3.1: Proposed Hypothesis model

3.1.1 Hypothesis H1: Implementation of QMS-Information Quality

Implementation of QMS requires an organization to adhere to certain standard procedures such as document control, record keeping, maintaining quality records etc. With the maintenance of these records and documents, information can be conveyed in a better and easy way to everyone in an organization. People can easily obtain whatever information they need and whenever they need. Moreover, when these documents are updated regularly, people can receive updated information and work accordingly. This will also result in people striving for continuous improvement in their work and hence, ultimately improve productivity and efficiency. Further, this will also result in work being done in accordance with latest standards, latest data and latest procedures. In this regard, the following hypothesis is being proposed:

H1: Implementation of QMS results in improvement in information quality.

3.1.2 Hypothesis H2: Information Quality-Design Performance

With improvement in information quality, people can use information in accordance with latest standards, they can have more clarity of procedures and specifications, and thus can strive to make further improvements in design of the process. If information is not easily available or accessible, or updated information is not available, people will not strive to make any changes or improvements. Therefore, this leads to the proposal of following hypothesis:

H2: Improvement in Information Quality results in improvement in design performance.

3.1.3 Hypothesis H3: Information Quality-Operating Performance

Improvement in information quality results in information on various operating factors such as process productivity, efficiency, process cycle times etc., being updated regularly. This can motivate operators to bring continuous improvement in processes, to improve various operating factors. Further, information can also be important to communicate to customers sometimes. Therefore, this leads to the proposal of following hypothesis:

H3: Improvement in Information Quality results in improvement in operating performance.

3.1.4 Hypothesis H4: Information Quality-Environmental Performance

If employees are regularly educated about benefits of improving environment at workplace, they will keep workplace neat and clean and will continually try to improve it. This may also result in strategic plans being made to improve environment at workplace, and policies will be developed to organize environment improvement activities and hence reduce health and safety risks. Therefore, this leads to the proposal of following hypothesis:

H4: Improvement in Information Quality positively results in improvement in environmental performance.

3.1.5 Hypothesis H5: Information Quality-Supplier Relationships

Supplier relationships are quite important in any supply chain. The quality problems at the supplier end, if left unsolved can go throughout the supply chain and ultimately affect the final customer. Better supplier relationships can definitely help to eliminate many of these quality problems. We expect that better information quality can also help an organization to improve their relationships with suppliers and serve the customer better. This includes trusting suppliers, regular information sharing with suppliers, providing technical assistance to suppliers to solve their problems, selecting suppliers based on quality of their product etc. Therefore, we propose the following hypothesis:

H5: Improvement in Information Quality positively impacts supplier relationships.

3.1.6 Hypothesis H6: Information Quality-Customer Relationships

The effect of improvement in information quality on customer relationships has also been studied. We expect that better information quality can help an organization to improve their relationships with customers in comparison to suppliers proposed above, as better information quality allows organization to trust and share information with customers and vice versa, to become aware of customer requirements, to get customer feedback on product and service quality etc., by which an organization is able to improve its products and services, upon feedback received from the customers. This improvement can ultimately lead to better business performance. Therefore, we propose the following hypothesis:

H6: Improvement in Information Quality positively impacts customer relationships.

3.1.7 Hypothesis H7: Design Performance, Operating Performance and Environmental Performance-Product Quality

Product quality has a great impact on the reputation of an organization. Delivering high quality products to customers can single handedly help an organization to grow its market share and increase sales. Better product designs, manufacturing performance and work environment greatly impact product quality. Better designs can help operators in ease of manufacture, improved sense of perception by customer and improved product reliability. Radovilsky et al. (2011) find that more than 50 % of the quality problems are associated with the manufacturing step of the supply chain. Better operating performance can help to reduce variances in product dimensions and manufacture better quality products. Conducive work environment can motivate employees to perform better on their jobs, and reduce health and safety risks. This can directly have an impact on product quality. Therefore, this leads to the proposal of following hypothesis:

H7: Improvement in design, operating and environmental performance positively impacts product quality.

3.1.8 Hypothesis H8: Supplier Relationships and Customer Relationships-Service Quality

Improvement in supplier relationships and customer relationships can help an organization in a long way. With improvement in supplier relationships, suppliers can improve their services, which will reduce raw material inventories at production site and customer will also provide assistance to suppliers in improving their processes and products. With improvements in customer relationships, manufacturers can get feedback from customers about their products and services, which may strive manufacturers to improve these, which will result in less customer complaints, and hence increase in sales and profitability. This leads to the proposal of following hypothesis:

H8: Improvement in Supplier and customer relationships positively impacts service quality.

3.1.9 Hypothesis H9: Product Quality and Service Quality-Competitive Priorities

Improving the product quality helps an organization to produce and deliver better quality and more reliable products, and reduce cost of quality, rework costs etc. Further, improvement in service quality can help in increased customer satisfaction, effective processes for handling of customer concerns and providing them better services etc. Better service quality further helps in improving supplier services like reduction in product delivery time from supplier, effective process for handling supplier problems etc. Therefore, it is believed that combination of better product and service quality can help an organization to improve on competitive priorities, and perform better with its competitors. This leads us to propose the following hypothesis:

H9: Improvement in product and service quality positively impacts a firm's competitive priorities.

3.1.10 Hypothesis H 10: Competitive Priorities-Business Performance

The better business performance is the bottom line for any business. Managers and CEOs want to ultimately see their organization performing better in terms of sales and profits. Improving upon its competitive priorities can help an organization to compete better with competitors, which can further lead to growth in its market share, increase in sales and ultimately increased profits. In this regard, we propose the following hypothesis:

H10: Improvement in a firm's competitive priorities positively impacts its business performance.

3.2 Survey Study

A survey study was conducted to collect data to test the ten proposed research hypotheses. This section gives an insight about survey study.

The research study aims to study the effect of implementation of Quality Management Systems such as ISO, TQM, APAP, AS standards etc., on various business performance factors. The reasons for the implementation of Quality Management Systems, their usage in daily practice and further, the effect of their implementation on business performance factors such as information quality, design performance, operating performance, environmental performance, supplier and customer relationships, product and service quality, competitive priorities and business performance is being studied. In this regard, a hypothesis model was proposed in the previous section, showing relationships among implementation of QMS and performance factors. Various hypotheses were proposed with respect to research hypothesized model. To collect data and test these hypotheses, a 9-page survey questionnaire was prepared, related to research hypothesized model.

3.2.1 Survey Instrument

The 9-page survey questionnaire was prepared to collect data to study the effect of implementation of Quality Management Systems on business performance, through improvement in various factors such as information quality, design performance, operating performance, environmental performance, supplier and customer relationships, product quality, service quality and competitive priorities. The factor, Implementation of Quality Management Systems includes implementation of QMS as a catalyst for change, use of QMS in daily practice and reasons for implementation of QMS. Information Quality includes information content, information format, information sharing, use of information related to quality, use of information for improving environment and use of information in process control. Service Quality includes supplier services, customer services and customer satisfaction. The questions related to each of the above mentioned factors were taken after a thorough literature review (Samson et al. 1999, Molina et al. 2007, Park et al. 2001, Kim et al. 2012, Terziovski et al. 2003, Singh 2008, Tari et al. 2007, Kaynak 2003, Koc 2007). The survey questionnaire is provided in Appendix A.

The survey-questionnaire was divided into two sections, Section A and Section B. The Section A asked general information about the respondent such as name of the organization they are working with or have worked with previously, job title, number of years of experience and their thoughts, comments and suggestions regarding the impact of implementation of Quality Management Systems on performance factors, from their own experience.

The Section B was divided into 11 dimensions. The questions in this section were prepared in accordance with proposed research hypothesis model. Dimension 1 focused on measuring implementation of Quality Management Systems as a catalyst for change, use of QMS in daily practice and reasons for implementation of QMS. In this dimension, respondents were also asked to enter the Quality Management Systems they are working with or have worked with previously. Dimension 2 assesses effect of implementation of QMS on information quality. In this dimension, information quality is further divided into sub-factors - information content, information format, information sharing, use of information related to quality, use of information for improving environment and use of information in process control. Respondents were also asked about their perception of good information quality. Dimensions 3,4,5,6 and 7 assess effect of improvement in information quality on design performance, operating performance, environmental performance, supplier relationships and customer relationships, respectively. In each of these dimensions, respondents were asked to give their perception of good design performance, good operating performance, good environmental performance, quality in supplier relationships and quality in customer relationships. Dimension 8 assesses the effect of improvement in design, operating and environmental performance on product quality. As with other dimensions, respondents were asked to give their perception of good product quality. Dimension 9 assesses the effect of improvement in supplier and customer relationships on service quality. Service Quality is further divided into sub-factors - supplier services, customer relationships and customer satisfaction. Like dimensions, respondents were asked to give their perception of good service quality. Dimension 10 assesses the effect of improvement in product and service quality on firm’s competitive priorities. Respondents were also asked about their organization’s competitive priorities. Finally, Dimension 11 assesses the effect of improvement in firm’s competitive priorities on their firm’s business performance. Respondents were also asked to give their perception of good business performance.

Each question in Section B of the survey questionnaire was answered using 1 to 5 Likert type scale (1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly agree).

3.2.2 Data Collection

The 9-page survey questionnaire was sent to experienced professionals, working in quality engineering departments in various organizations or to those who have previously worked with, and have number of years of experience working with various Quality Management Systems. The questionnaire was sent to professionals working with organizations such as Larsen and Toubro Limited, Bell Helicopter, Pratt and Whitney Canada, Bombardier etc. The questionnaire was sent to some of the respondents through e-mail, some were contacted personally and some of them were contacted through LinkedIn. Table 3.1 shows the profile of 30 respondents used for our research study.

Finally, a total of 32 questionnaires were received and 30 questionnaires were considered for analysis for our research. The responses to questionnaire were received from professionals with experience ranging from 2 - 42 years and working at engineer level, managers, directors, consultants, quality auditors and owners of organizations. Some responses from academicians were also received.

Table 3.1: Profile of survey respondents

No.	Job Title	Exp.	Company
1	Quality Systems Representative	>10	NIA
2	Consultant	9	Kraft Foods
3	Project Manager	11	StamSanat
4	Quality Analyst	7	TUV NORD &Fararay
5	Production Planning Manager	4	IK
6	Manufacturing Analyst	40	Pratt & Whitney
7	Assistant Professor	7	SCMS Business School
8	Quality Engineering Coordinator	30	Bombardier Aerospace
9	Assistant Manager	4	Larsen & Toubro Limited
10	Quality Manager	15	IKCO Automotive Company
11	Assistant Professor	5	Concordia University
12	QA Analyst	40	Tekalia Aeronautik Inc.
13	Consultant	34	-
14	Operation Program Engineer	2	Pratt & Whitney
15	Owner	25	SIGMu Management inc.
16	Quality Manager	25	Alstom Power
17	Lean Program Manager	22	Wesco Distribution
18	Supplier Quality Team Leader	4	Rolls Royce
19	QA & CM Engineer	12	Mechtronix Inc.
20	Quality Manager	12	Mechtronix Inc.
21	Supplier Development & Quality Engineering	14	Westport Innovations
22	Managing Director	10	The Quality Team Limited
23	Business Management Consultant	8	Business Management Consultant
24	-	-	Bell Helicopter
25	Quality Program Lead Auditor	30	Bell Helicopter
26	Manager Airworthiness	20+	Bell Helicopter
27	Quality Assurance Engineering Specialist	26	Bell Helicopter
28	Quality Manager	15	-
29	Owner	42	ActinQ
30	Quality Director	42	Allevo

3.3 Data Analysis Approach

The data collected from survey questionnaire was analyzed with the help of statistical software, IBM SPSS Statistics 21 and Microsoft office EXCEL. A number of tests were performed to determine validity of measurement variables and reliability of factors of our survey questionnaire. Finally, hypothesis testing was done to test proposed research hypotheses. This section discusses about the tests used in our data analysis approach.

3.3.1 Content Validity

A factor is generally considered to have good content validity, if there is a general notion that measurement variables cover almost all the aspects of factor, that measurement variables are expected to measure. The content validity is a subjective measure done by researchers. The measurement variables for each factor for our research study were selected after an extensive research literature review (Samson et al. 1999, Molina et al. 2007, Park et al. 2001, Kim et al. 2012, Terziovski et al. 2003, Singh 2008, Tari et al. 2007, Kaynak 2003, Koc 2007).

3.3.2 KMO Test

The Kaiser-Meyer-Olkin (KMO) test is done to check sampling adequacy of each factor. The value of KMO measure lies between 0 and 1. Kaiser (1974) recommended values of KMO above 0.5 for each factor in order to proceed with factor analysis. Further, KMO values between 0.5 and 0.7 are considered mediocre, between 0.7 and 0.8 are considered good and values greater than 0.9

are considered superb (Hutcheson and Sofroniou, 1999). The KMO test is carried out for each factor of our study, using IBM SPSS Statistics software. Table 3.2 summarizes the interpretation of KMO values.

Table 3.2: Consideration of KMO Test Values

KMO Test Value	Interpretation of KMO Value
Below 0.5	Unacceptable
Between 0.5 and 0.7	Mediocre
Between 0.7 and 0.8	Good
Above 0.9	Excellent

3.3.3 Reliability Analysis

Reliability Analysis is a measure of internal consistency of measurement variables to measure their associated factor. It is measured by calculating reliability coefficient, Cronbach alpha (α) value for each factor. In our analysis, it was calculated using IBM SPSS Statistics software. Cronbach alpha (α) values of greater than 0.7 are generally acceptable according to literature (Nunnally, 1978).

3.3.4 Construct validity

A measurement variable is considered to have construct validity if it measures the factor it is actually supposed to measure according to study. The construct validity of each measurement variable of our survey questionnaire is analyzed by calculating the factor loadings for each measurement variable on its respective factor. The factor loading value actually shows the extent to which a measurement variable measures its associated factor. These values are calculated using Principal Component Analysis (PCA) method in our analysis. Further to this, varimax rotation method is used to optimize and equalize the relative effect of sub-extracted factors, among measurement variables, if any.

Measurement variables that have a factor loading value less than 0.6 on their respective factors are eliminated from the analyses and factor loadings for remaining measurement variables are recalculated, using varimax rotation approach.

3.4 Hypothesis Testing

Hypothesis Testing is associated with testing of proposed relationship between two or more factors. The aim of hypothesis testing is to study the effect of independent variables on dependent variable. It is determined by calculating regression coefficients for each of the proposed hypothesis and then calculating significance of each relationship.

While carrying hypothesis testing, one factor is taken as dependent variable and other factor is taken as independent variable. There may be more than one independent variable, depending upon the proposed relationships among factors. The factor, whose effect is being studied is taken as independent variable and the affected factor due to change in independent factor is taken as dependent factor. Independent factors are also known as regressors and dependent variables are also known as regressands. A simple regression equation looks as following:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \ldots\ldots + \beta_iX_i + \mathcal{E}$$

where:

Y- Value of Dependent Factor

X_i – Value of i^{th} Independent Factor

β_0 - Value of dependent factor Y, when value of each independent factor, X_i is zero.

β_i – Change in the value of the dependent factor Y, with change in the value of the respective independent factor X_i, keeping all other independent factors constant.

$\mathcal{E}$ – Random explained factors not considered in our analysis, or residual error.

In our analysis, hypothesis testing is carried out using Linear Regression analysis approach (Schumacker and Lomax, 2010), although there are many types of regression analysis. The analysis is carried out using IBM SPSS 21 statistical software. More discussion about test statistics associated with hypothesis testing analysis is done below:

3.4.1 Correlation Coefficient

Correlation coefficient is a measure of the strength of relationship between two variables. It indicates the degree of linear association between them. Although there are many types of correlation coefficients, Pearson correlation coefficient is most commonly used to indicate the linear association and direction of linear association between two variables. The value of Pearson correlation coefficient lies between -1 and +1. The closer the value of correlation coefficient to +1 or to -1, the stronger is the relationship between two variables. Interpretation of values of correlation coefficient is done as follws:

- If the value of correlation coefficient is positive, it indicates a positive relationship between two variables. When value of one variable increases, the value of other variable also increases, and vice-versa.
- If the value of correlation coefficient is negative, it indicates a negative relationship between two variables. When value of one variable increases, the value of other variable decreases, and vice-versa.

3.4.2 Multiple R

Multiple R value indicates the correlation between two factors. This value is always indicated as positive while carrying hypothesis testing analysis, although correlation value between two factors may be negative. The value of correlation coefficient between two factors lies between -1 and 1; hence the value of Multiple R lies between 0 and 1.

3.4.3 R Square

R Square is also known as coefficient of determination. R Square value is the square of Multiple R value. It indicates percentage of total variance explained or predicted by independent factors in dependent factor. The value of R Square statistic lies between 0 and 1. This value is also an indication of goodness of fit of assumed model or relationship with empirical data. The closer the value of R Square to 1, the better is the model fit.

3.4.4 β value

β value is also known as standardized regression coefficient. The β_i value indicates the degree of association between independent factor X_i and dependent factor Y. It indicates the average change in the value of dependent factor Y, with one unit change in the value of one of the independent factors X_i, provided all other Xi's remain constant. The value of β lies from -1 to +1. The closer the value of β to 1 or to -1, the stronger is the relationship between independent factor and dependent factor. The value of β closer to zero indicates a weak relationship between independent factors and dependent factors. The perception of β values in hypothesis testing is discussed below:

- Positive value of β indicates positive association between independent factor and dependent factor, which means that value of dependent factor increases as the value of independent factor increases, and vice-versa.
- Similarly negative value of β indicates that value of dependent factor decreases as the value of independent factor increases, and vice-versa.
- A β value equal to zero or closer to zero indicates that the value of dependent factor may increase, decrease or remain constant with increase in the value of independent factor, and vice-versa.

3.4.5 P-value

The P-value indicates the validity of results of any research study. It is possible that value of β_i or any other statistic found in an analysis came by random chance. This situation will occur when sample used in a particular research study is not representative of population. If any value or relationship is indicated in a study by random chance, the study will not be useful for anyone and it will cast further doubts on results. The P-value indicates the probability of occurrence of a particular value by chance. The researcher always wants this value to be as closer to zero as possible.

When confirming the validity of results of any research, the P-value is used as significance level. Generally, the 0.05 value is taken as the cut-off significance level, i.e. the probability of getting a value of statistic by random chance should be less than or equal to 0.05. The researchers want the P-value to be less than 0.05, to confirm that a particular result has not occurred by random chance. If P-value is found to be greater than 0.05, it is generally concluded that a particular result may have been obtained by random chance. Different researchers use different P-value to confirm validity of results of their research. The P-values of 0.05 and 0.01 are most commonly used, but sometimes the value 0.10 is also used. The value above 0.10 is generally never used.

3.4.6 F-Test

F-statistic is the ratio of explained variability to unexplained variability in dependent factor Y. F-value is a statistical test used to make inference about the goodness of fit of the regression equation, i.e. about R Square value. It is used to predict whether all the independent factors, i.e. all Xi's collectively in a regression model are significantly useful in predicting the value of dependent factor Y. It is a global test which encompasses all the independent factors and tests their significance of predicting dependent factor. The following summarizes the steps of this test:

Step 1: Firstly, the two hypotheses are set up:

- Null Hypothesis H_0: All β_i values are equal to zero
- Alternative Hypothesis H_a: At least one of the β_i values is not equal to zero

Step 2: Calculation of test value of F-statistic.

Step 3: Calculation of $F_{Critical}$ value at some P-value.

Step 4: Making a Decision: If F-statistic > $F_{Critical}$, F-statistic lies in the rejection region

where P-value is less than 0.05. Therefore in this case, null hypothesis H_0 is rejected. If F-statistic < $F_{Critical}$, null hypothesis H_0 is not rejected. The following summarizes the interpretation of hypotheses:

- If null hypothesis H_0 is rejected, at least one of the β_i values is not equal to zero. Hence, it is concluded that the model as a whole is statistically significant and at least one of the values of independent factors X_i's significantly predict the value of dependent factor Y.

- If null hypothesis H_0 is not rejected, all β_i values are equal to zero. Hence, it is concluded that the values of independent factors do not significantly predict the value of dependent factor.

3.4.7 T-Test

T-test is a statistical test used to make an inference about the i^{th} β value, i.e. to check the statistical significance of the effect of i^{th} independent factor on dependent factor. It is very similar to F-Test discussed previously, with only difference that F-Test takes into account all the independent factors whereas T-Test does the same for each of the independent factor, X_i. The following summarizes the steps of this test:

Step 1: Firstly, the two hypotheses are set up:

- Null Hypothesis H_0: β_i value is zero, i.e. the change in its value has no effect on value of dependent factor
- Alternative Hypothesis H_a: β_i value is not equal to zero, i.e. there is some relationship between i^{th} independent factor X_i and dependent factor Y.

Step 2: Calculation of test value of T-statistic.

Step 3: Calculation of $T_{Critical}$ value at some P-value.

Step 4: Making a Decision: If T-statistic > $T_{Critical}$, T-statistic lies in the rejection region

where P-value is less than 0.05. Therefore in this case, null hypothesis H_0 is rejected. If T-statistic < $T_{Critical}$, null hypothesis H_0 is not rejected. The following summarizes the interpretation of hypotheses:

- If null hypothesis H_0 is rejected, at least one of the β_i values is not equal to zero. Hence, it is concluded that the model as a whole is statistically significant and at least one of the values of independent factors X_i's significantly predict the value of dependent factor Y.
- If null hypothesis H_0 is not rejected, all β_i values are equal to zero. Hence, it is concluded that the values of independent factors do not significantly predict the value of dependent factor.

Chapter 4: Survey Results

This chapter presents and discusses the results of the survey study.

4.1 Data Analysis

The collected data was analyzed with the help of statistical software IBM SPSS Statistics 21 (Grace-Martin and Sweet, 2012) and Microsoft office EXCEL.

Firstly, Kaiser-Mayer-Olkin (KMO) test was carried on each factor to check sampling adequacy. Then collected data was tested for reliability of all factors to check if measurement variables are reliable enough to measure the factor they are supposed to. Measurement variables were then tested for construct validity, by calculating factor loading value for each measurement variable on their respective factor. All these tests were carried out with IBM SPSS software.

Pairwise deletion method was used for all missing values, which means that only cases with missing values are deleted pairwise. This is preferred over Listwise deletion method as Listwise method deletes cases for all variables, which results in large loss of data. Replacing mean values with mean is also not preferred as replacing missing values with mean will result in non-integer values in our case.

Secondly, correlation matrix among factors of our research study was analyzed to check the issue of multicollinearity. This followed with analyzing and discussions on open ended questions asked in the survey and importance of each measurement variable according to respondents, by calculating overall mean for each measurement variable. The scores obtained from respondents were in the range from 1 to 5 (1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly agree). For the purpose of reporting the mean scores, the obtained scores were converted on a scale of 0.2 to 1, by dividing the obtained mean score by 5 (2). This was done to allow for the easy interpretation of mean scores.

Finally, hypothesis testing analysis was carried for each of the proposed hypothesis.

4.2 Content Validity

As measurement variables selected for our survey questionnaire were selected after an extensive research literature review, (Samson et al. 1999, Molina et al. 2007, Park et al. 2001, Kim et al. 2012, Terziovski et al. 2003, Singh 2008, Tari et al. 2007, Kaynak 2003, Koc 2007), we provide assurance that measurement variables used in our survey questionnaire have good content validity. Almost all the measurement variables of factors were covered in the survey questionnaire.

4.3 KMO Test

The KMO value of each factor of our study is found to be well above 0.5, except for competitive priorities factor and reasons for implementation of QMS sub-factor, but as obtained values are above 0.5, they are acceptable. So, we can proceed further with factor analysis. Table 4.1 shows the KMO values of each factor and sub-factors.

Table 4.1: KMO test values

No.	Factor	KMO value
1.	Implementation of Quality Management	
	Systems:	0.759
	As a Catalyst for Change	0.790
	Use of QMS in daily practice	0.566
	Reasons for implementation of QMS	
2.	Information Quality:	
	Information Content	0.858
	Information Format	0.765
	Information Sharing	0.650
	Use of Information	0.750
	Use of Information for Improving Environment	0.736
	Use of Information in Process Control	0.696
3.	Design Performance	0.777
4.	Operating Performance	0.860
5.	Environmental Performance	0.766
6.	Supplier Relationships	0.746
7.	Customer Relationships	0.852
8.	Product Quality	0.792
9.	Service Quality:	
	Supplier Services	0.785
	Customer Services	0.779
	Customer Satisfaction	0.776
10.	Competitive Priorities	0.517
11.	Business Performance	0.836

4.4 Reliability Analysis

The Cronbach alpha (α) values of factors are found to be lie between 0.772 (Use of information) and 0.955 (Product Quality), which are greater than the acceptable value of 0.7. The alpha (α) values clearly show that measurement variables of our study are reliable enough to measure the factors they are supposed to. Only the measurement variables retained after factor analysis were used in this analysis. Further, pairwise deletion method is used to deal with missing values, to avoid loss of large amount of data. Table 4.2 lists the Cronbach Alpha (α) values of each factor and sub-factor.

Table 4.2: Cronbach Alpha (α) values

No.	Factor	α value
1.	Implementation of Quality Management Systems	0.842
	As a Catalyst for Change	0.864
	Use of QMS in daily practice	0.830
	Reasons for implementation of QMS	
2.	Information Quality	
	Information Content	0.891
	Information Format	0.926
	Information Sharing	0.778
	Use of Information	0.827
	Use of Information for Improving Environment	0.863
	Use of Information in Process Control	0.853
3.	Design Performance	0.908
4.	Operating Performance	0.916
5.	Environmental Performance	0.864

6.	Supplier Relationships	0.893
7.	Customer Relationships	0.938
8.	Product Quality	0.966
9.	Service Quality	
	Supplier Services	0.887
	Customer Services	0.912
	Customer Satisfaction	0.894
10.	Competitive Priorities	0.807
11.	Business Performance	0.961

4.5 Construct validity

Measurement variables that had a factor loading value of less than 0.6 on their respect factor were eliminated from the analyses and factor loadings of remaining items were recalculated. The discussion of construct validity of each factor is as follows:

4.5.1 Implementation of Quality Management Systems

There are three sub-factors in Implementation of Quality Management Systems factor. They are Implementation of QMS as a catalyst for change, use of QMS in daily practice and reasons for implementation of QMS. Factor and reliability analysis for each of them is carried out separately, as each of them measures different aspect of implementation of QMS, and collectively they measure overall aspect of implementation of QMS. The factor analysis for each of the sub-factors of Implementation of QMS is as follows:

Implementation of QMS: As a Catalyst for change

The factor analysis of implementation of QMS as a catalyst for change resulted in values ranging between 0.69 and 0.86, showing that variables measured this sub-factor well. Table 4.3 lists all the loading values.

Table 4.3: Factor Analysis - Implementation of QMS: As a Catalyst for change

	Item	Loadings
A1	Base / Starting Point for Quality Improvement	0.71
A2	Discovery of improvement opportunities	0.84
A3	Introduce new practices	0.86
A4	Starting point for more advanced Quality practices	0.85
A5	Change Organizational culture	0.69

Implementation of QMS: Use of QMS in daily practice

The factor loading values of measurement variables of use of QMS in daily practice lie between 0.72 and 0.85. Table 4.4 shows the loading values for this analysis.

Table 4.4: Factor Analysis - Implementation of QMS: Use of QMS in daily practice

	Item	Loadings
B1	Documents created are used in Daily Practice	0.85
B2	Quality Management Systems are the part of regular routine	0.83
B3	System is well coordinated	0.83
B4	Integration with Practice already in place	0.81
B5	Tailored to the needs of organization	0.72

Implementation of QMS: Reasons for implementation of QMS

The factor analysis for reasons for implementation of QMS resulted in removal of C4, C9, C12 and C13, as each of them loaded less than 0.6, on each of the obtained sub-factors. The resulting items led to the formation of 3 factors. The new analysis again resulted in the removal of C7, as it loaded less than 0.6 on each of the 3 factors, in the rotated space. The remaining items finally resulted in 3 sub-factors, each factor loading value greater than 0.6. The three factors can be interpreted as implementation of QMS due to internal reasons, external reasons (Gain advantages in market) and implementation of QMS due to customer pressure. Table 4.5 lists all the loading values for the factors retained.

Table 4.5: Factor Analysis - Implementation of QMS: Reasons for implementation of QMS

	Item	Loadings			Factor
C1	Base for Quality Improvement	0.83			1
C2	Improve Customer Service	0.85			1
C3	Improve efficiency	0.84			1
C4	Change Organizational culture				R
C5	Gain Advantage in international markets		0.89		2
C6	Gain marketing benefits		0.90		2
C7	Anticipated Future customer requirements				R
C8	Be considered for tenders			0.85	3
C9	Increase market share				R
C10	Stay in Business		0.70		2
C11	Customer Pressure			0.88	3
C12	Establish long term relationships with customers				R
C13	Create Discipline in Organization				R

Factor 1 – Internal Reasons (C1, C2, C3)

Factor 2 – External reasons (Gain advantages in market) (C5, C6, C7)

Factor 3 – Implementation of QMS due to customer pressure (C8, C11)

4.5.2 Information Quality

There are six sub-factors in Information Quality factor. They are information content, information format, information sharing, use of information, use of information for improving environment and use of information in process control. Factor and reliability analysis for each of them is carried out separately, as each of them measures different aspect of information quality, and collectively they measure overall aspect of Information quality. The factor analysis for each of the sub-factors is as follows:

Information Quality: Information content

The factor analysis resulted in removal of one variable IC6, which alone loaded highly on other factor. The revised factor loadings range between 0.78 and 0.91, clearly showing that other variables measured the information content sub-factor quite well. Also, the removal of IC6 resulted in higher Cronbach α value of 0.891. Table 4.6 lists all the loading values for this analysis.

Table 4.6: Factor Analysis - Information Quality: Information content

	Item	**Loadings**
IC1	Information in records is complete & accurate	0.85
IC2	Information is useful in daily jobs	0.84
IC3	Information focuses on key business drivers	0.79
IC4	Information is relevant for decision making	0.91
IC5	Policies related to quality are defined clearly	0.78
IC6	Special department is in place for documents management	R

Information Quality: Information format

The factor loading analysis for Information format sub - factor is shown in the table 4.7. The factor loading values are found to be quite high, 0.93 and 0.94, showing variables measured the factor very well. The Cronbach α value is found to be 0.926, showing very good consistency of measurement variables.

Table 4.7: Factor Analysis - Information Quality: Information format

	Item	Loadings
IF1	Information is in Good appearance and format	0.94
IF2	Information is Comparable to other outputs (consistency)	0.94
IF3	Information is Easy to understand	0.93

Information Quality: Information sharing

The factor loading values for Information sharing sub-factor lie between 0.71 and 0.86, very much acceptable for our analyses. Table 4.8 shows the loading values for this analysis.

Table 4.8: Factor Analysis - Information Quality: Information sharing

	Item	Loadings
IS1	Data related to quality improvement is shared with customers & suppliers	0.71
IS2	Open and trusting work environment with customers & suppliers	0.72
IS3	Employees are willing to share information with each other	0.80
IS4	Smooth inter-departmental communication & coordination	0.86

Information Quality: Use of information

The factor analysis of use of information resulted in formation of two factors, QI1 – QI4 loaded highly on 1st factor, F1, QI6 – QI7 loaded highly on 2nd factor, F2, and QI5 loaded on both factors, but as its loading value is greater than 0.6 on 2nd factor, that value is retained. Varimax rotation was done on extracted factors to obtain revised factor loadings. The first factor can be interpreted as use of quality data and second factor can be interpreted as training regarding quality. Table 4.9 lists all the loading values for this analysis.

Table 4.9: Factor Analysis - Information Quality: Use of information

	Item	Loadings		Factor
QI1	Information on quality is regularly collected on all facets of business	0.82		1
QI2	Quality data is used as a tool to manage quality	0.85		1
QI3	Quality data is made available to managers & supervisors	0.89		1
QI4	Quality data is used to evaluate supervisor & managerial performance	0.76		1
QI5	Quality data & control charts are displayed at employee work stations		0.66	2
QI6	Quality related training is given to managers & supervisors		0.92	2
QI7	Training regarding “Total Quality Concept” is given to all employees		0.81	2

Factor 1: Use of quality data (QI1, QI2, QI3, QI4)

Factor 2: Training regarding quality (QI5, QI6, QI7)

<u>Information Quality: Use of information for improving environment</u>

The factor analysis of use of information for improving environment resulted in formation of two factors, QE1 – QE2 loaded highly on 2st factor, QI3 – QI7 loaded highly on 1st factor. Although revised factor loading for QE3 is 0.598, it is not removed as it is very close to our cut off value of 0.6. Varimax rotation is done on extracted factors to obtain revised values. The first factor can be interpreted as education regarding improving environment and second factor can be interpreted as plans and efforts to improve environment. The loadings values for this analysis are shown in the table 4.10.

Table 4.10: Factor Analysis - Information Quality: Use of information for improving environment

	Item	Loadings		Factor
QE1	Education is provided to employees regarding benefits of improving environment		0.89	2
QE2	Employees are educated regarding things causing environmental harm		0.89	2
QE3	Efforts are made to continually improve work environment	0.60		1
QE4	Strategic plans include reduction in waste targets	0.84		1
QE5	Environmental activities are regularly organized	0.72		1
QE6	Policies are developed to reduce and prevent health and safety risks	0.78		1
QE7	Firm has Long-term environmental strategic focus	0.81		1

Factor 1: Education regarding improving environment (QE3, QE4, QE5, QE6, QE7)

Factor 2: Plans and efforts to improve environment (QE1, QE2)

<u>Information Quality: Use of information in process control</u>

The factor analysis of use of information in process control again resulted in formation of two factors, QP1 – QP3 loaded highly on 2^{st} factor, QP4 – QP7 loaded highly on 1^{st} factor and QP8 loaded less than 0.6 on either factor and was hence removed from analysis. Varimax rotation was done on extracted factors to obtain revised factor loadings. The loadings for first factor range from 0.78 to 0.91 whereas loadings for second factor range from 0.67 to 0.95. The first factor can be interpreted as use of control charts and SPC techniques in process control whereas second factor can be interpreted as general use of information in improving processes. Table 4.11 lists the factor loading values for this analysis.

Table 4.11: Factor Analysis - Information Quality: Use of information in process control

	Item	**Loadings**		**Factor**
QP1	All production / service processes are regularly monitored		0.90	2
QP2	All work processes are regularly analysed for improvement		0.91	2
QP3	Processes in the plant are designed to be “fool proof”		0.78	2
QP4	Extensive use of SPC techniques to reduce variance in the process	0.74		1
QP5	Charts showing defect rates are posted on shop floor	0.87		1
QP6	Charts showing schedule compliance are posted on shop floor	0.67		1
QP7	Charts showing frequency of machine breakdowns are posted on shop floor	0.95		1
QP8	Information on productivity is readily available to employees			R

Factor 1: Use of control charts and SPC techniques in process control (QP4, QP5, QP6, QP7)

Factor 2: General use of information in improving processes (QP1, QP2, QP3)

4.5.3 Design Performance

The factor analysis of measurement variables of design performance factor resulted in values between 0.66 and 0.87, thereby showing that variables measured the factor well. Although, some values are slightly on the lower side, but all values are greater than our cut off value of 0.6. The Cronbach α value is found to be 0.908, showing very good consistency of variables to measure the factor. The factor loading values for this analysis are listed in the table 4.12.

Table 4.12: Factor Analysis - Design Performance

	Item	**Loadings**
DP1	Improved overall Product Performance	0.79
DP2	Improved Product Reliability	0.79
DP3	More Clarity of Product specifications and procedures	0.70
DP4	Improved coordination among departments involved in product design	0.81
DP5	Continual improvements are made in product design	0.87
DP6	Customer requirements are thoroughly analyzed in new product design process	0.84
DP7	Productivity is considered during Product Design process	0.66
DP8	Product Quality is given more importance than Product cost	0.68
DP9	New product designs are thoroughly reviewed	0.75

4.5.4 Operating Performance

Table 4.13 lists the factor loading values of measurement variables of operating performance factor. The values range between 0.74 and 0.89, thereby showing that variables measured the factor very well. The Cronbach α value is found to be

0.916, which is again very good. Although, the removal of OP7 may have resulted in slightly higher α value, but that is not recommended due to its significant factor loading value.

Table 4.13: Factor Analysis - Operating Performance

	Item	**Loadings**
OP1	Lower Product Defect Rates	0.89
OP2	Reduced Unit Production Costs	0.85
OP3	Reduced Process Cycle Times	0.84
OP4	Reduced cost of quality	0.84
OP5	Improved Product Design Quality	0.74
OP6	Improved Manufacturing Quality	0.86
OP7	Higher Productivity	0.74
OP8	Improved Product Delivery Performance	0.79

4.5.5 Environmental Performance

The factor loading analysis for Environmental performance factor is shown in the table 4.14. The analysis resulted in removal of EP4 for which value of factor loading was less than 0.6. The revised factor loadings lie between 0.68 and 0.87, which clearly shows that other variables measured the factor quite well. Also, the removal of EP4 resulted in higher α value of 0.864, showing good consistency of other variables to measure environmental performance factor.

Table 4.14: Factor Analysis - Environmental Performance

	Item	Loadings
EP1	Cleanliness and neatness	0.85
EP2	Continually strive for reduction in waste targets	0.86
EP3	Work environment is conducive to the well-being of all employees	0.87
EP4	Work environment is conducive to the development of all employees	R
EP5	Reduced Health and safety risks	0.77
EP6	Environmental ‘green’ protection issues are proactively managed	0.68

4.5.6 Supplier Relationships

The factor loading analysis for supplier relationships factor is summarized in table 4.15. The analysis resulted in the removal of variable SR4, for which factor loading value was less than 0.6. The values of loadings for remaining measurement variables range between 0.66 and 0.83, which are very much acceptable. The value of Cronbach α is found to be 0.893, showing good consistency of variables to measure environmental performance factor.

Table 4.15: Factor Analysis - Supplier relationships

	Item	Loadings
SR1	Suppliers are actively involved in new product development	0.75
SR2	Regular Information sharing between organization & suppliers	0.88
SR3	Long term relationships exist with suppliers	0.82
SR4	Quality is number one criterion in selecting suppliers	R

SR5	Climate of cooperation exists with suppliers	0.83
SR6	Technical assistance is provided to suppliers	0.75
SR7	Inspection of incoming parts has been reduced	0.70
SR8	Suppliers are selected based on quality of their product	0.66

4.5.7 Customer Relationships

The factor loading values for Customer Relationships factor are shown in the table 4.16. The factor analysis resulted in removal of three items, CR6, CR9 and CR14, for which value of factor loadings were less than 0.6. The values of loadings for other items range between 0.60 and 0.92. The value of Cronbach α value is found to be 0.938, showing very good consistency of variables to measure the factor.

Table 4.16: Factor Analysis - Customer relationships

	Item	**Loadings**
CR1	Firm is aware of the requirements of customers	0.86
CR2	Regular Information sharing between Organization & customers	0.81
CR3	Performance feedback data is collected from customers	0.86
CR4	Systematic processes in place for handling complaints	0.92
CR5	Misunderstandings between customers and organization are rare	0.60
CR6	Reduction in customer audits	R
CR7	Customers often visit our plant	0.63
CR8	Customers give feedback on quality & delivery performance	0.79

CR9	Data related to quality improvement is shared with customers	R
CR10	Customer complaints are used as a method to initiate improvements	0.84
CR11	External customer satisfaction is regularly measured	0.79
CR12	Customers are actively involved in Design and improvement of firm's products & services	0.74
CR13	Climate of cooperation exists with customers	0.73
CR14	Customers are involved in Strategic Planning	R

4.5.8 Product Quality

The factor loading analysis for product quality factor is summarized in table 4.17. The analysis resulted in removal of PQ6, for which value of loading was less than 0.6. The revised values of loadings range between 0.82 and 0.96, which are quite high, showing that other variables measure the factor quite well. The value of Cronbach α is found to be 0.966, showing excellent consistency of variables to measure factor.

Table 4.17: Factor Analysis - Product Quality

	Item	**Loadings**
PQ1	Improved overall Product Quality	0.93
PQ2	Reduced Variances in Manufactured Products	0.86
PQ3	Reduced Product defects	0.96
PQ4	Continuous control and improved key processes	0.91
PQ5	Improved Product performance & Reliability	0.85
PQ6	Improvement in Perceived Product Quality by customers	R
PQ7	Reduction in Scrap	0.92

PQ8	Reduction in Rework	0.89
PQ9	Improved Individual Process Performance	0.82

4.5.9Service Quality

There are three sub-factors in Service Quality factor. They are supplier relationships, customer services and customer satisfaction. Factor analysis for each of them is carried out separately, as each of them measures different aspect of service quality, and collectively they measure overall aspect of Service quality. The factor loading analysis for each of them is as follows:

Service Quality: Supplier Services

The factor loading values for all measurement variables in supplier services sub-factor are found to be between 0.65 and 0.82, which are acceptable for our analysis. The Cronbach α value is found to be 0.887, once again showing very good consistency of variables to measure supplier relationships factor. Table 4.18 lists all the loading values.

Table 4.18: Factor Analysis - Service Quality: Supplier Services

	Item	Loadings
SS1	Reduced Delivery lead time of purchased materials	0.82
SS2	Reduction in Incoming products inspection	0.78
SS3	Assistance is provided to suppliers in overcoming problems	0.77
SS4	Reduction in rejection of parts received from suppliers	0.87
SS5	Effective processes in place for handling supplier problems	0.77
SS6	Reduction in Raw material inventories	0.65
SS7	Increase in raw material inventory turnover	0.72

Service Quality: Customer Services

The factor loading values for all measurement variables of customer services sub-factor are found to be between 0.65 and 0.87, values very much acceptable. The Cronbach α value is 0.912, showing very good consistency of measurement variables to measure customer services factor. The table 4.19 lists all the factor loading values.

Table 4.19: Factor Analysis - Service Quality: Customer Services

	Item	**Loadings**
CS1	Effective processes are in place for handling customer complaints	0.87
CS2	Customer complaints have decreased	0.83
CS3	Increase in Customer Profitability	0.70
CS4	Every employee is willing to take initiative to solve customers' problems	0.70
CS5	Employees can solve the customers' problems well and rapidly	0.85
CS6	Customers' inquiries are answered immediately	0.83
CS7	Reduced Delivery lead-time of finished products/services to customer	0.65
CS8	Customers' problems are resolved to their satisfaction.	0.85

Service Quality: Customer satisfaction

The factor loading values for measurement variables of customer satisfaction sub-factor lie between 0.65 and 0.86, values quite good. The Cronbach α value is found to be 0.894, again showing very good consistency of variables to measure customer services factor. Table 4.20 lists all the factor loading values.

Table 4.20: Factor Analysis - Service Quality: Customer satisfaction

	Item	Loadings
CX1	Systematic goals are in place for customer satisfaction	0.64
CX2	Improvement in Perceived Product Quality by customers	0.74
CX3	Increased Customer Loyalty	0.86
CX4	Increased number of customers	0.82
CX5	Decrease in Customer Complaints	0.68
CX6	Increase in Sales	0.81
CX7	Customers are satisfied with the overall services of our company	0.86
CX8	Analysis of customer satisfaction is made	0.76

4.5.10 Competitive Priorities

The factor loading analysis for competitive priorities factor is shown in table 4.21. The analysis resulted in formation of 2 factors, CP1 to CP4 loaded highly on 1st factor, F1, CP5 and CP6 loaded highly on 2nd factor, F2. Varimax rotation was done on extracted factors to obtain revised factor loadings. The second factor can be interpreted as organization’s competitive priorities in Product flexibility.

Table 4.21: Factor Analysis - Competitive Priorities

	Item	Loadings		Factor
CP1	Reduced Cost of Quality	0.83		1
CP2	Reduced Unit Production Costs	0.75		1
CP3	Improved Product Delivery performance	0.70		1
CP4	Improved Customer Satisfaction	0.93		1
CP5	Improved Product Volume Flexibility		0.90	2
CP6	Improved Product Variety Flexibility		0.93	2

Factor 1: General competitive priorities (CP1, CP2, CP3, CP4)

Factor 2: Organization’s competitive priorities in Product flexibility (CP5, CP6)

4.5.11 Business Performance

All the measurement variables loaded significantly high on business performance factor. The values of factor loadings lie between 0.88 and 0.94, showing that variables measured the factor well. Also, the Cronbach alpha (α) value is found to be 0.961, which shows the excellent consistency of variables to measure business performance factor. Table 4.22 lists all the factor loading values.

Table 4.22: Factor Analysis - Business Performance

	Item	**Loadings**
BP1	Increased Profits	0.88
BP2	Growth in Market Share	0.91
BP3	Growth in Annual Sales	0.95
BP4	Increased return on Investment	0.91
BP5	Increased throughput	0.91
BP6	Increased Cash flow	0.94

4.6 Explained Variance

The measurement variables of our survey questionnaire are found to explain significant amount of variance in each factor. The percentage of explained variance of factors varies between 59 % (Supplier relationships) to 84 % (Business performance). This is found to be very significant in survey research studies. Only the measurement variables retained after factor analysis were used in this analysis. This is done as we are concerned with only the variance explained by measurement variables, which are actually retained after the analysis. Table 4.23 lists the variance explained by measurement variables of each factor.

Table 4.23: Variance explained in each factor

No.	Factor	Variance explained (%)
1.	Implementation of Quality Management Systems	62.47 %
	As a Catalyst for Change	65.47 %
	Use of QMS in daily practice	60.00 %
	Reasons for implementation of QMS	
2.	Information Quality	
	Information Content	69.78 %
	Information Format	87.38 %
	Information Sharing	60.31 %
	Use of Information	74.68 %
	Use of Information for Improving Environment	72.88 %
	Use of Information in Process Control	75.26 %
3.	Design Performance	58.79 %
4.	Operating Performance	67.91 %
5.	Environmental Performance	65.61 %
6.	Supplier Relationships	58.77 %
7.	Customer Relationships	61.34 %
8.	Product Quality	79.87 %
9.	Service Quality	
	Supplier Services	59.20 %
	Customer Services	62.43 %
	Customer Satisfaction	59.86 %
10.	Competitive Priorities	75.89 %
11.	Business Performance	84.03 %

4.7 Factor Correlations

Table 4.24 shows the correlation matrix among factors of our study. Most of the correlations are found to be statistically significant at 0.01 significance level. There is some correlation among factors as improvement in one factor may result in improvement in some other factor. All the measurement variables were considered for this analysis, irrespective of their factor loading values. Further, pairwise deletion method is used to deal with missing values, to avoid loss of large amount of data.

As all the correlation values are less than 0.9, multicollinearity doesn't seem to be problem among factors considered in our research.

Table 4.24: Correlation matrix among factors

	QMS	INF	DP	OP	EP	SR	CR	PQ	SQ	CP	BP
QMS	1										
INF	0.77**	1									
DP	0.65**	0.66**	1								
OP	0.60**	0.52**	0.57**	1							
EP	0.53**	0.37	0.46*	0.78**	1						
SR	0.66**	0.61**	0.61**	0.70**	0.66**	1					
CR	0.67**	0.72**	0.75**	0.70**	0.54**	0.73**	1				
PQ	0.72**	0.66**	0.57**	0.78**	0.69**	0.81**	0.73**	1			
SQ	0.71**	0.72**	0.66**	0.68**	0.63**	0.77**	0.70**	0.80**	1		
CP	0.68**	0.61**	0.65**	0.53**	0.42*	0.79**	0.73**	0.66**	0.85**	1	
BP	0.56**	0.51**	0.70**	0.63**	0.52**	0.78**	0.64**	0.71**	0.74**	0.78**	1

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

4.8 Descriptive Statistics

This section analyzes and discusses open ended questions asked in the survey and importance of each measurement variable, according to responses obtained from respondents.

4.8.1 Implementation of Quality Management Systems

From the responses received, the respondents are found to have worked with QMS such as ISO 9000 Standards, AS9100, CAR Standards, TQM, Six Sigma, ISO 14001, TS 16949 etc. Most of them were found to have worked with ISO 9000 standards, as these are implemented in most of the organizations and AS9100, as a lot of responses were received from professionals working in aerospace industry.

From the survey analysis, it is found that top reasons for which organizations implement QMS as a catalyst for bringing change are to change organizational culture, discovery of improvement opportunities etc. Table 4.25 lists all the reasons with their respective mean values.

Table 4.25: Mean values - Implementation of QMS: As a catalyst for change

Item	Mean
Base / Starting Point for Quality Improvement	0.71
Discovery of improvement opportunities	*0.75*
Introduce new practices	0.73
Starting point for more advanced Quality practices	0.69
Change Organizational culture	*0.75*

Table 4.26 lists all the mean values of use of QMS in daily practice. The values shows that documents created as part of QMS are indeed used in daily practice, they are tailored to the needs of the organization and their practice is already in place.

Table 4.26: Mean values - Implementation of QMS: Use in Daily Practice

Item	Mean
Documents created are used in Daily Practice	*0.74*
Quality Management Systems are the part of regular routine	0.69
System is well coordinated	0.70
Integration with Practice already in place	0.73
Tailored to the needs of organization	0.73

The major reasons for implementation of QMS are found to be the mix of both internal and external reasons, such as improve efficiency, improve customer service, customer pressure, stay in business etc. Among internal reasons, improve efficiency is found to have highest value, with base for quality improvement and improve customer service, not to far. Among external reasons, customer pressure is found to have highest value. This analysis clearly shows that some organizations are implementing QMS for internal reasons and some for external reasons. Table 4.27 shows the mean values of reasons for implementation of QMS.

Table 4.27: Mean values - Implementation of QMS: Reasons for implementation of QMS

Item	Mean
Base for Quality Improvement	0.76
Improve Customer Service	0.76
Improve efficiency	*0.78*
Change Organizational culture	0.69
Gain Advantage in international markets	0.71
Gain marketing benefits	0.71
Anticipated Future customer requirements	0.68
Be considered for tenders	0.74
Increase market share	0.70
Stay in Business	0.75
Customer Pressure	0.76
Establish long term relationships with customers	0.69
Create Discipline in Organization	0.74

4.8.2 Information Quality

From the survey analysis, it is found that most respondents consider good information quality to be accurate, reliable and precise information etc. Some of the most common responses received are listed below:

- Clear processes and procedures that are easy to understand and follow
- Relevant, actionable, appropriate level of detail, cost effective, clear and simple, helpful and useful

- Information should reflect not only the measurement of the organization's business processes but the effect that the organization's output has on the organization's customer base.
- Needs to meet the requirements of clauses 4.2.3 and 4.2.4 of ISO 9001:2008 i.e. legible, retrievable, protected from damage and retained for a period determined by the organization. In addition to that, it needs to be complete and to meet the needs of the organization and the requirements for mandatory records within ISO 9001:2008
- Relevant, up to date, accurate, easy to use and understand, worth the cost, reliable information
- Easy to read procedures and work instructions and good training practice for employees
- Accurate & Precise information
- Information easy to understand and easy to locate

Table 4.28 lists mean values of Information content sub-factor. The respondents agree with most of the items in this sub-factor. The score of item "Information focuses on key business drivers" is found to be on slightly lower side.

Table 4.28: Mean values - Information Quality: Information content

Item	**Mean**
Information in records is complete & accurate	0.74
Information is useful in daily jobs	*0.77*
Information focuses on key business drivers	0.69

Information is relevant for decision making	0.76
Policies related to quality are defined clearly	0.75
Special department is in place for documents management	0.71

Table 4.29 lists mean values of Information format sub-factor. The respondents almost agree with all items with scores found between 0.71 and 0.76.

Table 4.29: Mean values - Information Quality: Information format

Item	Mean
Information is in Good appearance and format	0.72
Information is Comparable to other outputs (consistency)	0.71
Information is Easy to understand	*0.76*

The mean values of items in Information sharing sub-factor are found between 0.70 and 0.76, showing that respondents almost agree with these items. Table 4.30 lists the mean values of all items.

Table 4.30: Mean values - Information Quality: Information sharing

Item	Mean
Data related to quality improvement is shared with customers & suppliers	0.75
Open and trusting work environment with customers & suppliers	*0.76*
Employees are willing to share information with each other	0.70
Smooth inter-departmental communication & coordination	0.71

The mean values of items in Use of information sub-factor are found between 0.66 and 0.79. Table 4.31 lists the mean values of all items. The values for items “Quality data is used to evaluate supervisor & managerial performance” and “Information on quality is regularly collected on all facets of business” are on the lower side, which may be due to the fact that a lot of other information is used in these aspects, and information on quality and quality data may make only very less amount of total information.

Table 4.31: Mean values - Information Quality: Use of information

Item	Mean
Information on quality is regularly collected on all facets of business	0.69
Quality data is used as a tool to manage quality	*0.79*
Quality data is made available to managers & supervisors	0.75
Quality data is used to evaluate supervisor & managerial performance	0.66
Quality data & control charts are displayed at employee work stations	0.74
Quality related training is given to managers & supervisors	0.76
Training regarding “Total Quality Concept” is given to all employees	0.74

Table 4.32 lists mean values of Use of information in improving environment sub-factor. The respondents almost agree with all items, with scores found between 0.72 and 0.81. Policies developed to reduce and prevent health and a safety risk is found to have highest mean value, shows complete agreement.

Table 4.32: Mean values - Information Quality: Use of information in improving environment

Item	Mean
Education is provided to employees regarding benefits of improving environment	0.74
Employees are educated regarding things causing environmental harm	0.74
Efforts are made to continually improve work environment	0.79
Strategic plans include reduction in waste targets	0.76
Environmental activities are regularly organized	0.72
Policies are developed to reduce and prevent health and safety risks	*0.81*
Firm has Long-term environmental strategic focus	0.75

Table 4.33 lists mean values of Use of information in process control sub-factor. The mean values are found to be between 0.68 and 0.80.

Table 4.33: Mean values - Information Quality: Use of information in process control

Item	Mean
All production / service processes are regularly monitored	0.78
All work processes are regularly analysed for improvement	0.76
Processes in the plant are designed to be "fool proof"	0.70
Extensive use of SPC techniques to reduce variance in the process	0.68
Charts showing defect rates are posted on shop floor	0.78
Charts showing schedule compliance are posted on shop floor	*0.80*
Charts showing frequency of machine breakdowns are posted on shop floor	0.71
Information on productivity is readily available to employees	0.73

4.8.3 Design Performance

From the survey analysis, it is found that respondents have different views of good design performance. Some consider it to be satisfying all customer needs in a cost effective way, some think designs easy producible or manufacturable etc. Some of the most common responses received are listed below:

- Conformance to standards, specifications and customer requirements.
- Engineer change order reduced to a bare minimum after final design release.
- Design that take into consideration producible at all aspect (tool, material, inspection, fabrication, consistency).
- Design must conform to customer requirements (quality, price, schedule expectations, function)
- Limiting the number of change requests. Have a good & formalized design / peer review process with high skill experts and all stakeholders involved (all functions).
- Designs which meet the req. of overall customer solution yet are optimized for cost, quality and lead time.

Table 4.34 lists mean values of Design Performance factor. The most significant items are found to be thorough review of new product designs, improved overall product performance and analyzing customer requirements in new product design process. The item, product quality is given more importance than product cost, is found to be less significant compared to other, meaning thereby that product cost is given equal or more importance than product quality during design process. This calls for further research in this area.

Table 4.34: Mean values - Design Performance

Item	Mean
Improved overall Product Performance	0.82
Improved Product Reliability	0.79
More Clarity of Product specifications and procedures	0.81
Improved coordination among departments involved in product design	0.80
Continual improvements are made in product design	0.74
Customer requirements are thoroughly analyzed in new product design process	0.81
Productivity is considered during Product Design process	0.76
Product Quality is given more importance than Product cost	0.67
New product designs are thoroughly reviewed	*0.85*

4.8.4 Operating Performance

Some of the responses received for good operating performance are listed below:

- Producing a Quality product that meets customer requirements at the lowest rejection rate.
- Efficient operations without rework.
- Ability to meet design requirements and specifications in a timely and cost-effective manner.

- Well defined outputs of processes, well defined process owners and well defined process measurements.
- Products are produced to specification with minimal rejects in time to meet customer delivery requirements.

The mean values of measurement variables of operating performance factor are listed in table 4.35. The mean values of items range between 0.74 and 0.81, which shows that respondents agreement with all items. Lower product defect rates, reduced cost of quality and improved manufacturing quality are found to have highest values, followed closely by other items.

Table 4.35: Mean values - Operating Performance

Item	**Mean**
Lower Product Defect Rates	*0.81*
Reduced Unit Production Costs	0.74
Reduced Process Cycle Times	0.77
Reduced cost of quality	0.81
Improved Product Design Quality	0.77
Improved Manufacturing Quality	*0.81*
Higher Productivity	0.74
Improved Product Delivery Performance	0.78

4.8.5 Environmental Performance

Some of the responses received for good operating performance are listed below:

- Use of practices and materials that are environmentally friendly. Expanded definition may include health and safety, but that is not included in the usual definition
- Minimization of risk of environmental damage combined with good compliance with applicable legal and other requirements
- A good EMS generally follows the adoption of an environmental policy. The environmental policy formally outlines a company's commitments to environmental management and commonly includes commitments to reduce waste, pollution, energy and resource use, sets objectives and targets and reviews the company's environmental performance
- Good Environmental Performance: Responding to be a better Corporate Citizen, and to comply with increasing government regulations worldwide. At P&WC we've established the Green Engine Program. The program aims to ensure that company products are designed, produced and operated to minimize environmental impact throughout their life cycle
- Product is designed with small environmental footprint

The mean values of measurement variables of environmental performance factor are found to be between 0.69 and 0.83, showing that respondents agree with all the items. The item, reduced health and safety risk is found to have highest value.

Table 4.36: Mean values - Environmental Performance

Item	Mean
Cleanliness and neatness	0.69
Continually strive for reduction in waste targets	0.74
Work environment is conducive to the well-being of all employees	0.75
Work environment is conducive to the development of all employees	0.74
Reduced Health and safety risks	*0.83*
Environmental ‘green’ protection issues are proactively managed	0.71

4.8.6 Supplier Relationships

Following are some of the responses for quality in supplier relationships:

- In providing clear and accurate information on the product the supplier has to provide and your expectation.
- Supply of products and services which do not need rework and meet the contracted req. 1^{st} time.
- Customer and supplier establish an integrated supply chain relationship based on clear standards and requirements in meeting product specifications and maintaining relevant process control, in a timely manner
- The organization’s expectations for quality must be clearly communicated to every supplier. Supplier performance should be measured and the results communicated back to the supplier in a timely, consistent, ongoing manner.
- Open and frank communication between customer and supplier to develop a mutually beneficial relationship.

- Close communication, Long-term relationship, Cross functional team Shared quality information, Involve suppliers early in product and process development with suppliers.
- Team up with world class suppliers with robust quality systems and continuous improvement tools.
- Clear communications of requirements. Timely response to Supplier queries

Table 4.37 lists mean values of measurement variables of supplier relationships factor. The values are found to be between 0.69 and 0.77, which shows respondents almost agree with items in supplier relationships. As expected, regular information sharing between organization & suppliers and climate of cooperation with suppliers is found to have highest value.

Table 4.37: Mean values - Supplier Relationships

Item	Mean
Suppliers are actively involved in new product development	0.70
Regular Information sharing between organization & suppliers	*0.77*
Long term relationships exist with suppliers	0.73
Quality is number one criterion in selecting suppliers	0.69
Climate of cooperation exists with suppliers	*0.77*
Technical assistance is provided to suppliers	0.76
Inspection of incoming parts has been reduced	0.69
Suppliers are selected based on quality of their product	0.73

4.8.7Customer Relationships

Following are some of the responses for quality in customer relationships:

- Providing customers with safe & reliable products & provision of accurate services.
- Ability to establish a win-win partnership in meeting customer's requirements in a cost-effective and price-effective manner, and become a repeat, preferred supplier.
- Open and frank communication between the organization and its customers to ensure the customer requirements are fully understood and are met
- Customers and suppliers have the same goal—to satisfy end user. The better the supplier quality, the better the supplier's long-term position, because the customer will have better quality. Because both the customer and suppliers have limited resources, they must work together as partners to maximize their return on investment.
- Deliver the highest level of integrated services and support that result in an enjoyable experience for our customers. We accomplish this by understanding our customer's business and by providing quality, value-added solutions.

Table 4.38 lists mean values of measurement variables of customer relationships factor. Respondents agree with most of the items in this factor. Some items are not fully agreed upon by organizations such as involvement of customers in strategic planning, involvement of customers in design and improvement of firm's products & services.

Table 4.38: Mean values - Customer Relationships

Item	Mean
Firm is aware of the requirements of customers	0.82
Regular Information sharing between Organization & customers	0.75
Performance feedback data is collected from customers	*0.84*
Systematic processes in place for handling complaints	0.81
Misunderstandings between customers and organization are rare	0.68
Reduction in customer audits	0.70
Customers often visit our plant	0.70
Customers give feedback on quality & delivery performance	0.74
Data related to quality improvement is shared with customers	0.68
Customer complaints are used as a method to initiate improvements	0.76
External customer satisfaction is regularly measured	0.79
Customers are actively involved in Design and improvement of firm's products & services	0.64
Climate of cooperation exists with customers	0.75
Customers are involved in Strategic Planning	0.54

4.8.8 Product Quality

Following are some of the responses for good product quality:

- The product's ability to fulfill the expectations and needs set by the end user.
- Products produced with little or no defects

- A product that meets customer requirements as expressed by design/contract specifications.
- Product meets or exceeds customer requirements
- Product that meets customer requirements and functions effectively for at least the defined service life.
- Product quality are the characteristics of products or services that depend on its ability to demonstrate its function, among others, the overall durability, reliability, accuracy, ease of operation and repair product attributes are also other products to satisfy consumer needs and wants.

The mean values of measurement variables of product quality factor lie between 0.75 and 0.82, thereby showing agreement of respondents to all items of this factor. Reduced products defects, Continuous control and improved key processes, improved overall Product Quality and Reduced Variances in Manufactured Products are found to have highest score, followed closely by others. Table 4.39 lists all the values.

Table 4.39: Mean values - Product Quality

Item	Mean
Improved overall Product Quality	0.80
Reduced Variances in Manufactured Products	0.80
Reduced Product defects	*0.82*
Continuous control and improved key processes	0.81
Improved Product performance & Reliability	0.80
Improvement in Perceived Product Quality by customers	0.81

Reduction in Scrap	0.77
Reduction in Rework	0.79
Improved Individual Process Performance	0.75

4.8.9 Service Quality

Following are some of the responses received for good service quality:

- An assessment of how well a delivered service conforms to the client's expectations. Provision of accurate, understandable & reliable answers
- Service delivery that meets customer requirements as expressed by design/contract specifications (engineering services) or defined performance metrics.
- Quick, friendly but also able to quickly solve the problem
- Delivery of service that meets or exceeds customer requirements.
- Service that meets agreed service levels and results in problem resolution at the earliest opportunity.
- Fast response to customer needs and priorities.
- Having a Quality Management System that provides processes and procedures to establish and maintain a Quality Assurance Program to comply with customers' requirements.

The mean values of supplier services sub-factor are shown in the table 4.40. The values of items lie between 0.66 and 0.79, thereby showing a positive response for most of the items.

Table 4.40: Mean values - Service Quality: Supplier Services

Item	Mean
Reduced Delivery lead time of purchased materials	0.72
Reduction in Incoming products inspection	0.69
Assistance is provided to suppliers in overcoming problems	0.76
Reduction in rejection of parts received from suppliers	0.75
Effective processes in place for handling supplier problems	*0.79*
Reduction in Raw material inventories	0.70
Increase in raw material inventory turnover	0.66

The mean values of customer services sub-factor are shown in the table 4.41. The values of items lie between 0.68 and 0.82, thereby showing a positive response for most of the items. The item, Effective processes are in place for handling customer complaints, has highest mean value, indicating that effective processes for handling complaints are foremost for effective customer services.

Table 4.41: Mean values - Service Quality: Customer Services

Item	Mean
Effective processes are in place for handling customer complaints	*0.82*
Customer complaints have decreased	0.73
Increase in Customer Profitability	0.68
Every employee is willing to take initiative to solve customers' problems	0.70
Employees can solve the customers' problems well and rapidly	0.70
Customers' inquiries are answered immediately	0.75
Reduced Delivery lead-time of finished products/services to customer	0.74
Customers' problems are resolved to their satisfaction.	0.78

The mean values of customer satisfaction sub-factor are shown in the table 4.42. The values of items lie between 0.74 and 0.70, which shows respondents almost agree with items in customer satisfaction. The items, Increased Customer Loyalty and Improvement in Perceived Product Quality by customers have the highest mean values.

Table 4.42: Mean values - Service Quality: Customer Satisfaction

Item	**Mean**
Systematic goals are in place for customer satisfaction	0.74
Improvement in Perceived Product Quality by customers	0.78
Increased Customer Loyalty	*0.79*
Increased number of customers	0.76
Decrease in Customer Complaints	0.74
Increase in Sales	0.74
Customers are satisfied with the overall services of our company	0.76
Analysis of customer satisfaction is made	0.77

4.8.10 Competitive Priorities

From the survey analysis, it is clear that different organizations have different competitive priorities. Some of the most common responses received are listed below:

- Quality, Lead time, Flexibility, Cost
- New product development
- To provide preferred capabilities and solutions at competitive prices.

- Increase market share
- Increase in sales
- On time delivery
- Customer satisfaction
- Best quality at competitive price

The mean values of items of competitive priorities factor is shown in table 4.43. Improved customer satisfaction was found to have highest value, thereby showing organization's focus to satisfy a customer. The mean values for others lie between 0.70 and 0.79, showing agreement of respondents with all the items.

Table 4.43: Mean values - Competitive Priorities

Item	**Mean**
Reduced Cost of Quality	0.79
Reduced Unit Production Costs	0.76
Improved Product Delivery performance	0.78
Improved Customer Satisfaction	*0.83*
Improved Product Volume Flexibility	0.73
Improved Product Variety Flexibility	0.70

4.8.11 Business Performance

From the survey analysis, it is found that respondents have different views in good business performance. Some consider profits to be important and some consider quality and customer satisfaction to be more important than profits. Some of the most common responses received are listed below:

- Good Business Performance will result in Increase in profits and market share
- Profits do not take priority over quality and satisfaction
- Meeting or exceeding return on investment
- Ability to manage capabilities and internal cost structures in a manner that supports sustained growth and profitability
- Delivery of value to customers and organization's stakeholders/shareholders.
- Planning, including the setting of appropriate and challenging objectives, and then achieving those objectives
- The business is profitable
- Good use of cash flow, Good order intake, good delivery on quality on time, increase market share.
- Meeting customers' needs for quality and price

Table 4.44 lists mean values of items of business performance factor. All the values are around 0.8, which means organizations agree with items of business performance factor. Increased profits and growth in annual sales have the highest values, whereas other items lie just behind these.

Table 4.44: Mean values - Business Performance

Item	Mean
Increased Profits	*0.81*
Growth in Market Share	0.79
Growth in Annual Sales	*0.81*
Increased return on Investment	0.80
Increased throughput	0.79
Increased Cash flow	0.80

4.9 Hypothesis Testing

In this section, we present and discuss the results of the hypotheses proposed in Chapter 3. Hypothesis testing is carried using Linear Regression approach in IBM SPSS 21 statistical software.

4.9.1 Link between Implementation of QMS and information quality

The statistics for hypothesis H1 are shown in the table 4.45. The R square value is found to be 0.593, which means that 59.3 % of the variance in information quality is explained by the implementation of QMS factor. The value indicates a very good model. The standardized β value is 0.770, which shows positive relationship between implementation of QMS and information quality. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between implementation of QMS and information quality occurred by random chance, hence we conclude that β = 0 and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β value between Implementation of QMS and information quality is a true value and sample is truly representative of population.*

The calculated β value is validated by F-test, which is found to be statistically significant at p=0.000. As in this model, there is only one predictor variable, implementation of QMS, t-test value is also statistically significant at p=0.000, same as F-Test.

Therefore, we reject the null hypothesis, and accept the alternative hypothesis that implementation of QMS is positively related to information quality, and hence conclude that implementation of QMS indeed results in improvement in information quality.

Table 4.45: Regression Statistics: Hypothesis H1

Multiple R	0.770		
R Square	0.593		
Standardized β value	0.770		
F-Test	40.81	p = 0.000	Significant
T-test	6.384	p = 0.000	Significant
Hypothesis H1 is accepted, positive relationship between Implementation of QMS and information quality.			

4.9.2 Link between information quality and design performance

The regression statistics for hypothesis H2 are shown in the table 4.46. The R square value is found to be 0.440; 44 % of the variance in design performance is explained by the information quality. The value indicates a relatively good model. The standardized β value is 0.663, which shows positive relationship between implementation of information quality and design performance. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between information quality and design performance occurred by random chance, hence we conclude that β = 0 and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β value between information quality and design performance is a true value and sample is truly representative of population.*

The calculated β value is validated by F-test and t-test, which are statistically significant at p=0.000. Therefore, we reject the null hypothesis, and accept the alternative hypothesis that Improvement in information quality is positively related to design performance, and conclude that improvement in information quality results in improvement in design performance.

Table 4.46: Regression Statistics: Hypothesis H2

Multiple R	0.663		
R Square	0.440		
Standardized β value	0.663		
F-Test	19.634	p = 0.000	Significant
T-Test	4.431	p = 0.000	Significant
Hypothesis H2 is accepted, positive relationship between information quality and design performance.			

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4.9.3 Link between information quality and operating performance

The regression statistics for hypothesis H3 are listed in the table 4.47. The R square value is found to be 0.276, which means that 27.6 % of the variance in operating performance is explained by information quality. The standardized β value of 0.525 shows positive relationship between information quality and operating performance. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between information quality and operating performance occurred by random chance, hence we conclude that β = 0 and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β value between information quality and operating performance is a true value and sample is truly representative of population.*

The calculated β value is validated by F-test and t-test, which are found to be statistically significant at p=0.000. Therefore, we reject the null hypothesis, and accept the alternative hypothesis that improvement in information quality is positively related to operating performance, and conclude that improvement in information quality results in improvement in operating performance.

Table 4.47: Regression Statistics: Hypothesis H3

Multiple R	0.525		
R Square	0.276		
Standardized β value	0.525		
F-Test	10.285	p = 0.000	Significant
T-Test	3.207	p = 0.000	Significant
Hypothesis H3 is accepted, positive relationship between information quality and operating performance.			

4.9.4 Link between information quality and environmental performance

The regression statistics for hypothesis H4 are shown in the table 4.48. The R square value is found to be 0.138, which means that only 13.8 % of the variance in environmental performance is explained by information quality. The value clearly gives the indication of a weak model. The standardized β value of 0.371 shows positive relationship between information quality and environmental performance. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between information quality and environmental performance occurred by random chance, hence we conclude that β = 0 and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β value between information quality and environmental performance is a true value and sample is truly representative of population.*

The calculated β value is validated by F-test and t-test and is found to be statistically insignificant, as p = 0.052 > 0.05. As p-value > 0.05, there is not enough evidence to reject the null hypothesis, and hence we conclude that there is not enough evidence that improvement in information quality indeed results in improvement environmental performance. We conclude that this value might have occurred by random chance and there is a need to collect more data to validate the relationship between information quality and environmental performance.

Table 4.48: Regression Statistics: Hypothesis H4

Multiple R	0.371		
R Square	0.138		
Standardized β value	0.371		
F-Test	4.160	p = 0.052	Not Significant
T-Test	2.039	p = 0.052	Not Significant
Hypothesis H4 is not accepted, positive relationship between information quality and environmental performance cannot be validated.			

4.9.5 Link between information quality and supplier relationships

Regression statistics for hypothesis H5 are shown in the table 4.49. The R square value is found to be 0.373; indicating 37.3 % of the variance in supplier relationships is explained by the information quality. The value indicates a relatively good model. The standardized β value is 0.611, which shows positive relationship between information quality and environmental performance. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between information quality and supplier relationships occurred by random chance, hence we conclude that β = 0 and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β value between information quality and environmental performance is a true value and sample is truly representative of population.*

The calculated β value is validated by F-test and t-test, which are statistically significant at p=0.000. Therefore, we reject the null hypothesis, and accept the alternative hypothesis that improvement in information quality is positively related to supplier relationships, and hence conclude that improvement in information quality results in improvement in supplier relationships.

Table 4.49: Regression Statistics: Hypothesis H5

Multiple R	0.611		
R Square	0.373		
Standardized β value	0.611		
F-Test	16.051	p = 0.000	Significant
T-Test	4.006	p = 0.000	Significant
Hypothesis H5 is accepted, positive relationship between information quality and supplier relationships.			

4.9.6 Link between information quality and customer relationships

Regression statistics for hypothesis H6 are shown in the table 4.50. The R square value is found to be 0.519, meaning 51.9 % of the variance in customer relationships is explained by information quality. The value indicates a good model. The standardized β value is found to be 0.720, which shows positive relationship between information quality and supplier relationships. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between information quality and customer relationships occurred by random chance, hence we conclude that β = 0 and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β value between information quality and customer relationships is a true value and sample is truly representative of population.*

The calculated β value is F-test and t-test are found to be statistically significant at p=0.000. Therefore, we reject the null hypothesis, and accept the alternative hypothesis that improvement in information quality is positively related to customer relationships, and conclude that improvement in information quality results in improvement in customer relationships.

Table 4.50: Regression Statistics: Hypothesis H6

Multiple R	0.720		
R Square	0.519		
Standardized β value	0.720		
F-Test	28.040	p = 0.000	Significant
T-Test	5.295	p = 0.000	Significant
Hypothesis H6 is accepted, positive relationship between information quality and customer relationships.			

4.9.7 Link between design, operating & environmental performances and product quality

In this case, factors design, operating & environmental performances were firstly tested for multicollinearity among them. For regression analysis to proceed successfully, there should be no multicollinearity among factors design, operating & environmental performance. This was checked with the help values of variance inflation factor. The value of variance inflation factors were found to be 1.477, 2.907 and 2.519 whereas a value greater than 10 indicates presence of multicollinearity. As all the values of variance inflation factors are less than 10, we conclude that there is no presence of multicollinearity among factors design, operating & environmental performance. Therefore, we can proceed further to multiple regression analysis approach.

Regression statistics for hypothesis H7 are listed in the table 4.51. The R square value is found to be 0.650; meaning 65.9 % of the variance in the factor product quality is explained collectively by design, operating and environmental performances. The value indicates a very good model. The standardized β values are found to be 0.177, 0.519 and 0.208 for design, operating and environmental performances respectively. These values show positive relationship between design performance and product quality, between operating performance and product quality, and between environmental performance and product quality. We test the validity of these β values by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β_i values between each of design, operating & environmental performance and product quality occurred by random chance, hence we conclude that $\beta_i = 0$ and sample is not representative of population.*

Alternative Hypothesis H_1: *Calculated β_i values between each of design, operating & environmental performance and product quality are true values and sample is truly representative of population.*

F-test is found to be statistically significant at p=0.000, which means that model as a whole is significant. T-test is found to be significant only for operating performance, but for design performance and for environmental performance, t-test is found to be statistically insignificant, as p>0.05 for both.

Therefore, we reject the null hypothesis, and accept the alternative hypothesis that improvement in operating performance is positively related to product quality, and conclude that improvement in operating performance results in improvement in product quality.

Also, for design performance and environmental performance, we cannot reject the null hypothesis, and hence conclude that improvement in each, design performance and environmental performance does not result in improvement in product quality. We conclude that these values might have occurred by random chance and there is a need to collect more data to validate the relationships between design performance and product quality, and between environmental performance and product quality.

Table 4.51: Regression Statistics: Hypothesis H7

Multiple R	0.806		
R Square	0.650		
Standardized β values			
(Design Performance)	0.177		
(Operating Performance)	0.519		
(Environmental Performance)	0.208		
F-Test	13.593	p = 0.000	Significant
T-Test			
(Design Performance)	1.153	p = 0.261	Not Significant
(Operating Performance)	2.412	p = 0.025	Significant
(Environmental Performance)	1.036	p = 0.312	Not Significant
Hypothesis H7 is partially accepted, positive relationship between operating performance and product quality, between design performance and product quality and between environmental performance and product quality, positive relationship cannot be validated.			

Table 4.52: Multicollinearity Statistics: Hypothesis H7

Variance Inflation factors (VIF)	
VIF (Design Performance)	1.477
VIF (Operating Performance)	2.907
VIF (Environmental Performance)	2.519

4.9.8 Link between supplier relationships & customer relationships and service quality

In this regression analysis, factors supplier and customer relationship were firstly tested for multicollinearity. For regression analysis to proceed successfully, there should be no multicollinearity between factors supplier relationships and customer relationships. In this case, this was checked with the help of 3 tests - T-test, correlation test and variance inflation factor. T-test and correlation test indicates presence of multicollinearity but variance inflation factor do not indicate any presence of multicollinearity between supplier relationships and customer relationships. The value of variance inflation factor is found to be 2.11, whereas a value greater than 10 indicates presence of multicollinearity. As two tests indicate presence of multicollinearity but one test do not indicate any presence of multicollinearity, it leads to a controversial conclusion regarding the presence of multicollinearity between factors, supplier relationships and customer relationships.

Although, problem of multicollinearity can be eliminated by removing one of the two regressor variables, but in this case, it is not recommended as the effects of improvement of both regressor variables, supplier relationships and customer relationships are important to measure improvement in service quality. So it is recommended for future researchers in this field to collect more data to possibly eliminate problem of multicollinearity between regressor variables.

The summary of three tests done to detect multicollinearity between regressor variables is given below:

1. $T_{test} > T_{Critical}$ - indicates presence of multicollinearity.
2. $R_{SR,\,SQ} + R_{CR,\,SQ} > R_{SR,\,CR}$ - indicates presence of multicollinearity.
3. Variance Inflation factor, $VIF_{SR} = VIF_{CR} = 2.11 < 10$ – does not indicate the presence of multicollinearity.

4.9.9 Link between product quality & service quality and competitive priorities

In this regression analysis, factors product quality and service quality were firstly tested for multicollinearity between them. For regression analysis to proceed successfully, there should be no multicollinearity between factors product quality and service quality. In this case again, this was checked with the help 3 tests - T-test, correlation test and variance inflation factor. T-test and correlation tests indicate presence of multicollinearity but variance inflation factor do not indicate any presence of multicollinearity between product quality and service quality. The value of variance inflation factor is found to be 2.76, whereas a value greater than 10 indicates presence of multicollinearity. As two tests indicate presence of multicollinearity but one test do not indicated any presence of multicollinearity, it leads to a controversial conclusion regarding the presence of multicollinearity between factors, product quality and service quality.

Although, problem of multicollinearity can be eliminated by removing one of the two regressor variables, but in this case, it is not recommended as the effects of improvement of both regressor variables, product quality and service quality are important to measure improvement in competitive priorities. So it is recommended for future researchers in this field to collect more data to possibly eliminate problem of multicollinearity between regressor variables.

The summary of three tests done to detect multicollinearity between regressor variables is given below:

1. $T_{test} > T_{Critical}$ - indicates presence of multicollinearity.
2. $R_{PQ, CP} + R_{SQ, CP} > R_{PQ, SQ}$ - indicates presence of multicollinearity.
3. Variance Inflation factor, $VIF_{PQ} = VIF_{SQ} = 2.76 < 10$ – does not indicate the presence of multicollinearity.

4.9.10 Link between competitive priorities and business performance

The regression analysis for hypothesis H10 is shown in the table 4.53. The R square value is found to be 0.608, indicating 60.8 % of the variance in business performance is explained by competitive priorities. This value indicates a very good model. The standardized β value is found to be 0.780, which shows positive relationship between competitive priorities and business performance, as predicted earlier. We test the validity of β value by testing null and alternative hypotheses, which are as follows:

Null hypothesis H_0: *Calculated β value between competitive priorities and business performance occurred by random chance, and hence conclude that β = 0 and sample is not representative of population*.

Alternative Hypothesis H_1: *Calculated β value between competitive priorities and business performance is a true value and sample is truly representative of population*.

Therefore, we reject the null hypothesis, and accept the alternative hypothesis that improvement in competitive priorities is positively related to business performance, and conclude that improvement in competitive priorities indeed results in improved business performance.

Table 4.53: Regression Statistics: Hypothesis H10

Multiple R	0.780		
R Square	0.608		
Standardized β value	0.780		
F-Test	34.079	p = 0.000	Significant
T-Test	5.838	p = 0.000	Significant
Hypothesis H10 is accepted, positive relationship between competitive priorities and business performance.			

4.10 Validation of Results

Table 4.54 presents validation of results of our survey study with the results of some of the previous research done in the area of implementation of QMS. It can be seen that majority of our results are supported by those existing in literature, other than business performance and operating performance which are only partially supported by literature. The new findings from our study are identification of new factors such as environmental performance, information quality and service quality (more detailed) and their importance in assessing the impact of QMS on business organizations. Also, in our thesis, all the business performance factors are considered in a single model, which is missing from research literature, which is the contribution of present study to the existing field of knowledge on QMS impact on business performance.

Table 4.54: Validation of results

Factor	**Supported / Not**	**Research Study**
Supplier Relationships	Supported	Molina et al. (2007), Kaynak (2003)
Customer Relationships	Supported	Molina et al. (2007)
Product Quality	Supported	Singh (2008), Kaynak (2003), Kannan et al. (2007), Kannan et al. (2005)
Business Performance	Supported	Singh (2008), Molina et al. (2007), Kaynak (2003), Terziovski et al. (2003), Tari et al. (2007), Tan et al. (1999), Koc (2007), Mann et al. (1994)

Information Quality	Supported	Kaynak (2003), Kim et al. (2012)
Service Quality	Supported	Kaynak (2003), Kannan et al. (2007)
Business Performance	Not Supported	Naveh et al. (2005), Adams (1999)
Operating Performance	Supported	Naveh et al. (2005), Kaynak (2003), Lo et al. (2009)
Operating Performance	Partially Supported	Samson et al. (1999)
Process Management	Partially Supported	Kim et al. (2012)
Design Performance	Supported	Kim et al. (2012)
Process Management	Supported	Tari et al. (2007), Kaynak (2003)
Organizational Performance	Not Supported	Rahman (2001)
Competitive Priorities	Supported	Koc (2007), Kannan et al. (2005)

Chapter 5: Conclusions

5.1 Conclusions

In this thesis, our main goal was to study impact of implementation of Quality Management Systems on various business performance factors namely information quality, design performance, operating performance, environmental performance, supplier relationships, customer relationships, product quality, service quality and competitive priorities. To study these relationships, hypothesis model was proposed to show the impact of implementation of QMS on these performance factors, showing how the improvement in one factor brings the improvement in other, and ultimately affects the business performance. Survey study was performed to collect data for our research.

The results of our study clearly indicate that organizations often implement QMS as a catalyst for change and organizations use QMS in daily practice. Most of the proposed hypotheses are found to have significant positive relationship, whereas factors of two of the hypotheses are found to have multicollinearity effects. Not enough significance is found in hypothesis H4 to validate relationship between information quality and environmental performance. Further, in hypothesis H7, not enough statistical significance is found to validate the relationship between design performance and product quality and between environmental performance and product quality. It is recommended for future researchers to collect more data or test the relationship each between design performance and product quality and between environmental performance and product quality.

To validate the results of our study, we compared them with those available in literature. The factors supported by literature are product quality, information quality, supplier relationships, customer relationships, service quality whereas some of the factors such as business performance, operating performance and process management are only partially supported. Based on the findings, we can say that the contribution of our thesis is identification of new factors such as environmental performance, information quality and service quality (more detailed) and their importance in assessing the impact of QMS on business organizations.

5.2 Future Works

The future works to extend the proposed study are as follows:

- Firstly, in this work, Quality Management Systems has been considered as a single factor. In future, impact of a specific element of QMS on a specific performance factor can be studied. Also, study can be done to study impact of implementation of specific QMS such as TQM, ISO etc. This can help organizations to bring about improvements in some particular elements of QMS.

- Secondly, sample size of the survey study can be increased to incorporate views from more number of Quality Management Professionals. This can also possibly help to eliminate multicollinearity problems that occurred in our research.

- Thirdly, study can be conducted with respect to specific continents, as work culture of organizations differs in different continents. Moreover, internet can be used for data collection, which will help to reach more number of professionals and can help to collect more data. Further, this will also make work easier for respondents.

- Fourthly, hypothesis model and measurement variables of performance factors can be modified according to specific type of industry. Then hypotheses can be tested for specific type of organizations and impact of implementation of QMS in different types of organizations can be compared. Similarly, organizations implementing different QMS can also be compared. This can help us to understand which QMS is more successful.

- Further, this analysis can be extended to check if the results are not obtained only due to some specific organizations and these organizations are not subduing the effects of other organizations. Comparing results of large scale industry with small scale industries is recommended in this case.

- For all the proposed hypotheses, causal analysis should be carried out to check whether some factor not taken in analysis is not causing the relationship between proposed factors. This will help to further strengthen the relationship between proposed hypotheses and validate our results.

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Web Links

1. http://www.floppybunny.org/robin/web/virtualclassroom/stats/statistics2/pca1.pdf

2. http://staff.neu.edu.tr/~ngunsel/files/Lecture%2011.pdf

3. http://courses.washington.edu/urbdp520/UDP520/

4. http://www.public.iastate.edu/~alicia/stat328/notes.htm

5. http://depts.washington.edu/lecturer/528-Sp05/Notes/

APPENDIX A: QUESTIONNAIRE

SECTION A: General Information

1. Organization: ____
2. Phone: ____
3. Job Title: ____
4. Total Experience (No. of Years): ____
5. Years of Experience in Current Position: _______________________________________
6. Please indicate any thoughts, comments or suggestions regarding the impact of implementation of quality development programs from your own experience

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SECTION B: Implementation of Quality Management Systems (QMS)

Which Quality Management Systems you are involved in?

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Dimension 1: Implementation of Quality Management Systems

In your organization, are QMS implemented as a Catalyst for Change?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Base / Starting Point for Quality Improvement	1	2	3	4	5
Discovery of improvement opportunities	1	2	3	4	5
Introduce new practices	1	2	3	4	5
Starting point for more advanced Quality practices	1	2	3	4	5
Change Organizational culture	1	2	3	4	5

Do you use Quality Management Systems in daily practice?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Documents created are used in Daily Practice	1	2	3	4	5
Quality Management Systems are the part of regular routine	1	2	3	4	5
System is well coordinated	1	2	3	4	5
Integration with Practice already in place	1	2	3	4	5
Tailored to the needs of organization	1	2	3	4	5

What are the reasons for implementation of Quality Management Systems?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Base for Quality Improvement	1	2	3	4	5
Improve Customer Service	1	2	3	4	5
Improve efficiency	1	2	3	4	5
Change Organizational culture	1	2	3	4	5
Gain Advantage in international markets	1	2	3	4	5
Gain marketing benefits	1	2	3	4	5
Anticipated Future customer requirements	1	2	3	4	5
Be considered for tenders	1	2	3	4	5
Increase market share	1	2	3	4	5
Stay in Business	1	2	3	4	5
Customer Pressure	1	2	3	4	5
Establish long term relationships with customers	1	2	3	4	5
Create Discipline in Organization	1	2	3	4	5

Dimension 2: Information Quality:

According to you, what is good Information Quality?

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What do you think about the effect of implementation of QMS on Information content?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Information in records is complete & accurate	1	2	3	4	5
Information is useful in daily jobs	1	2	3	4	5
Information focuses on key business drivers	1	2	3	4	5
Information is relevant for decision making	1	2	3	4	5
Policies related to quality are defined clearly	1	2	3	4	5
Special department is in place for documents management	1	2	3	4	5

What do you think about the effect of implementation of QMS on Information format?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Information is in Good appearance and format	1	2	3	4	5
Information is Comparable to other outputs (consistency)	1	2	3	4	5
Information is Easy to understand	1	2	3	4	5

What do you think about the effect of implementation of QMS on Information Sharing?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Data related to quality improvement is shared with customers & suppliers	1	2	3	4	5
Open and trusting work environment with customers & suppliers	1	2	3	4	5
Employees are willing to share information with each other	1	2	3	4	5
Smooth inter-departmental communication & coordination	1	2	3	4	5

What do you think about the effect of implementation of QMS on use of Information?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Information on quality is regularly collected on all facets of business	1	2	3	4	5
Quality data is used as a tool to manage quality	1	2	3	4	5
Quality data is made available to managers & supervisors	1	2	3	4	5
Quality data is used to evaluate supervisor & managerial performance	1	2	3	4	5
Quality data & control charts are displayed at employee work stations	1	2	3	4	5
Quality related training is given to managers & supervisors	1	2	3	4	5
Training regarding “Total Quality Concept” is given to all employees	1	2	3	4	5

What do you think about the effect of implementation of QMS on use of Information for improving Environment?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Education is provided to employees regarding benefits of improving environment	1	2	3	4	5
Employees are educated regarding things causing environmental harm	1	2	3	4	5
Efforts are made to continually improve work environment	1	2	3	4	5
Strategic plans include reduction in waste targets	1	2	3	4	5
Environmental activities are regularly organized	1	2	3	4	5
Policies are developed to reduce and prevent health and safety risks	1	2	3	4	5
Firm has Long-term environmental strategic focus	1	2	3	4	5

What do you think about the effect of implementation of QMS on Use of Information in Process Control?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

All production / service processes are regularly monitored	1	2	3	4	5
All work processes are regularly analysed for improvement	1	2	3	4	5
Processes in the plant are designed to be “fool proof”	1	2	3	4	5
Extensive use of SPC techniques to reduce variance in the process	1	2	3	4	5
Charts showing defect rates are posted on shop floor	1	2	3	4	5
Charts showing schedule compliance are posted on shop floor	1	2	3	4	5
Charts showing frequency of machine breakdowns are posted on shop floor	1	2	3	4	5
Information on productivity is readily available to employees	1	2	3	4	5

Dimension 3: Design Performance

According to you, what is good design performance?

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What do you think about the effect of improvement in Information Quality on design performance?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Improved overall Product Performance	1	2	3	4	5
Improved Product Reliability	1	2	3	4	5
More Clarity of Product specifications and procedures	1	2	3	4	5
Improved coordination among departments involved in product design	1	2	3	4	5
Continual improvements are made in product design	1	2	3	4	5
Customer requirements are thoroughly analyzed in new product design process	1	2	3	4	5
Productivity is considered during Product Design process	1	2	3	4	5
Product Quality is given more importance than Product cost	1	2	3	4	5
New product designs are thoroughly reviewed	1	2	3	4	5

Dimension 4: Operating Performance:

According to you, what is good operating performance?

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What do you think about the effect of improvement in Information Quality on operating performance?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Lower Product Defect Rates	1	2	3	4	5
Reduced Unit Production Costs	1	2	3	4	5
Reduced Process Cycle Times	1	2	3	4	5
Reduced cost of quality	1	2	3	4	5
Improved Product Design Quality	1	2	3	4	5
Improved Manufacturing Quality	1	2	3	4	5
Higher Productivity	1	2	3	4	5
Improved Product Delivery Performance	1	2	3	4	5

Dimension 5: Environmental Performance:

According to you, what is good Environmental Performance?

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What do you think about the effect of improvement in Information Quality on environmental performance?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Cleanliness and neatness	1	2	3	4	5
Continually strive for reduction in waste targets	1	2	3	4	5
Work environment is conducive to the well-being of all employees	1	2	3	4	5
Work environment is conducive to the development of all employees	1	2	3	4	5
Reduced Health and safety risks	1	2	3	4	5
Environmental ‘green’ protection issues are proactively managed	1	2	3	4	5

Dimension 6: Supplier Relationships:

How do you define Quality in Supplier Relationships?

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What do you think about the effect of improvement in Information Quality on supplier relationships?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Suppliers are actively involved in new product development	1	2	3	4	5
Regular Information sharing between organization & suppliers	1	2	3	4	5
Long term relationships exist with suppliers	1	2	3	4	5
Quality is number one criterion in selecting suppliers	1	2	3	4	5
Climate of cooperation exists with suppliers	1	2	3	4	5
Technical assistance is provided to suppliers	1	2	3	4	5
Inspection of incoming parts has been reduced	1	2	3	4	5
Suppliers are selected based on quality of their product	1	2	3	4	5

Dimension 7: Customer Relationships:

How do you define Quality in Customer Relationships?

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What do you think about the effect of improvement in Information Quality on Customer Relationships?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Firm is aware of the requirements of customers	1	2	3	4	5
Regular Information sharing between Organization & customers	1	2	3	4	5
Performance feedback data is collected from customers	1	2	3	4	5
Systematic processes in place for handling complaints	1	2	3	4	5
Misunderstandings between customers and organization are rare	1	2	3	4	5
Reduction in customer audits	1	2	3	4	5
Customers often visit our plant	1	2	3	4	5
Customers give feedback on quality & delivery performance	1	2	3	4	5
Data related to quality improvement is shared with customers	1	2	3	4	5
Customer complaints are used as a method to initiate improvements	1	2	3	4	5
External customer satisfaction is regularly measured	1	2	3	4	5
Customers are actively involved in Design and improvement of firm's products & services	1	2	3	4	5
Climate of cooperation exists with customers	1	2	3	4	5
Customers are involved in Strategic Planning	1	2	3	4	5

Dimension 8: Product Quality

According to you, what is good Product Quality?

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What do you think about the effect of improvement in Design, Operating & Environmental Performance on Product Quality?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Improved overall Product Quality	1	2	3	4	5
Reduced Variances in Manufactured Products (More Consistency in outputs)	1	2	3	4	5
Reduced Product defects	1	2	3	4	5
Continuous control and improved key processes	1	2	3	4	5
Improved Product performance & Reliability	1	2	3	4	5
Improvement in Perceived Product Quality by customers	1	2	3	4	5
Reduction in Scrap	1	2	3	4	5
Reduction in Rework	1	2	3	4	5
Improved Individual Process Performance	1	2	3	4	5

Dimension 9: Service Quality:

According to you, what is good Service Quality?

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What do you think about the effect of improvement in Supplier relationships on Supplier Services?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Reduced Delivery lead time of purchased materials	1	2	3	4	5
Reduction in Incoming products inspection	1	2	3	4	5
Assistance is provided to suppliers in overcoming problems	1	2	3	4	5
Reduction in rejection of parts received from suppliers	1	2	3	4	5
Effective processes in place for handling supplier problems	1	2	3	4	5
Reduction in Raw material inventories	1	2	3	4	5
Increase in raw material inventory turnover	1	2	3	4	5

What do you think about the effect of improvement in Customer Relationships on Customer Services?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Effective processes are in place for handling customer complaints.	1	2	3	4	5
Customer complaints have decreased	1	2	3	4	5
Increase in Customer Profitability	1	2	3	4	5
Every employee is willing to take initiative to solve customers' problems	1	2	3	4	5
Employees can solve the customers' problems well and rapidly	1	2	3	4	5
Customers' inquiries are answered immediately	1	2	3	4	5
Reduced Delivery lead-time of finished products/services to customer	1	2	3	4	5
Customers' problems are resolved to their satisfaction.	1	2	3	4	5

What do you think about the effect of improvement in Customer Relationships on Customer Satisfaction?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Systematic goals are in place for customer satisfaction	1	2	3	4	5
Improvement in Perceived Product Quality by customers	1	2	3	4	5
Increased Customer Loyalty	1	2	3	4	5
Increased number of customers	1	2	3	4	5
Decrease in Customer Complaints	1	2	3	4	5
Increase in Sales	1	2	3	4	5
Customers are satisfied with the overall services of our company	1	2	3	4	5
Analysis of customer satisfaction is made	1	2	3	4	5

Dimension 10: Competitive Priorities:

What is your organization's Competitive Priorities?

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What do you think about the effect of improvement in Product & Service Quality on your firm's competitive priorities?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Reduced Cost of Quality	1	2	3	4	5
Reduced Unit Production Costs	1	2	3	4	5
Improved Product Delivery performance	1	2	3	4	5
Improved Customer Satisfaction	1	2	3	4	5
Improved Product Volume Flexibility	1	2	3	4	5
Improved Product Variety Flexibility	1	2	3	4	5

Dimension 11: Business Performance:

According to you, what is good Business performance?

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What do you think about the effect of improvement in Competitive Priorities on your firm's Business Performance?

5: Strongly Agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly Disagree

Increased Profits	1	2	3	4	5
Growth in Market Share	1	2	3	4	5
Growth in Annual Sales	1	2	3	4	5
Increased return on Investment	1	2	3	4	5
Increased throughput	1	2	3	4	5
Increased Cash flow	1	2	3	4	5

Thank You very much for taking time to fill this questionnaire

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APPENDIX B: Factors and Associated Items of Survey Questionnaire

Factor 1: <u>Implementation of Quality Management Systems</u> (QMS)

Catalyst for Change

A1: Base / Starting Point for Quality Improvement
A2: Discovery of improvement opportunities
A3: Introduce new practices
A4: As a Starting point for more advanced Quality practices
A5: Change Organizational culture

Use in daily practice

B1: Documents created are used in Daily Practice
B2: Quality Management Systems are the part of regular routine
B3: System is well coordinated
B4: Integration with Practice already in place
B5: Tailored to the needs of organization

Reasons for implementation of Quality Management Systems

C1: Base for Quality Improvement
C2: Improve Customer Service
C3: Improve efficiency
C4: Change Organizational culture
C5: Gain Advantage in international markets
C6: Gain marketing benefits
C7: Anticipated Future customer requirements
C8: Be considered for tenders
C9: Increase market share
C10: Stay in Business
C11: Customer Pressure
C12: Establish long term relationships with customers
C13: Create Discipline in Organization

Factor 2: <u>Information Quality</u> (IQ)

Information content

IC1: Information in records is complete & accurate
IC2: Information is useful in daily jobs
IC3: Information focuses on key business drivers
IC4: Information is relevant for decision making
IC5: Policies related to quality are defined clearly

IC6: Special department is in place for documents management

Information format

IF1: Information is in Good appearance and format
IF2: Information is Comparable to other outputs (consistency)
IF3: Information is Easy to understand

Information Sharing

IS1: Data related to quality improvement is shared with customers & suppliers
IS2: Open and trusting work environment with customers & suppliers
IS3: Employees are willing to share information with each other
IS4: Smooth inter-departmental communication & coordination

Use of Information

QI1: Information is regularly collected on all facets of business
QI2: Quality data is used as a tool to manage quality
QI3: Quality data is made available to managers & supervisors
QI4: Quality data is used to evaluate supervisor & managerial performance
QI5: Quality data & control charts are displayed at employee work stations
QI6: Quality related training is given to managers & supervisors
QI7: Training regarding "Total Quality Concept" is given to all employees

Use of Information for improving Environment

QE1: Education is provided to employees regarding benefits of improving environment
QE2: Employees are educated regarding things causing environmental harm
QE3: Efforts are made to continually improve work environment
QE4: Strategic plans include reduction in waste targets
QE5: Environmental activities are regularly organized
QE6: Policies are developed to reduce and prevent health and safety risks
QE7: Firm has Long-term environmental strategic focus

Use of Information in Process Control

QP1: All production / service processes are regularly monitored
QP2: All work processes are regularly analyzed for improvement
QP3: Processes in the plant are designed to be "fool proof"
QP4: Extensive use of SPC techniques to reduce variance in the process
QP5: Charts showing defect rates are posted on shop floor
QP6: Charts showing schedule compliance are posted on shop floor
QP7: Charts showing frequency of machine breakdowns are posted on shop floor
QP8: Information on productivity is readily available to employees

Factor 3: Design Performance (DP)

DP1: Improved overall Product Performance
DP2: Improved Product Reliability
DP3: More Clarity of Product specifications and procedures
DP4: Improved coordination among departments involved in product design
DP5: Continual improvements are made in product design
DP6: Customer requirements are thoroughly analyzed in new product design process
DP7: Productivity is considered during Product Design process
DP8: Product Quality is given more importance than Product cost
DP9: New product designs are thoroughly reviewed

Factor 4: Operating Performance (OP)

OP1: Lower Product Defect Rates
OP2: Reduced Unit Production Costs
OP3: Reduced Process Cycle Times
OP4: Reduced cost of quality
OP5: Improved Product Design Quality
OP6: Improved Manufacturing Quality
OP7: Higher Productivity
OP8: Improved Product Delivery Performance

Factor 5: Environmental Performance (EP)

EP1: Cleanliness and neatness
EP2: Continually strive for reduction in waste targets
EP3: Work environment is conducive to the well-being of all employees
EP4: Work environment is conducive to the development of all employees
EP5: Reduced Health and safety risks
EP6: Environmental ‘green’ protection issues are proactively managed

Factor 6: Supplier Relationships (SR)

SR1: Suppliers are actively involved in new product development
SR2: Regular Information sharing between organization & suppliers
SR3: Long term relationships exist with suppliers
SR4: Quality is number one criterion in selecting suppliers
SR5: Climate of cooperation exists with suppliers
SR6: Technical assistance is provided to suppliers
SR7: Inspection of incoming parts has been reduced
SR8: Suppliers are selected based on quality of their product

Factor 7: <u>Customer Relationships</u> (CR)

CR1: Firm is aware of the requirements of customers
CR2: Regular Information sharing between Organization & customers
CR3: Performance feedback data is collected from customers
CR4: Systematic processes in place for handling complaints
CR5: Misunderstandings between customers and organization are rare
CR6: Reduction in customer audits
CR7: Customers often visit our plant
CR8: Customers give feedback on quality & delivery performance
CR9: Data related to quality improvement is shared with customers
CR10: Customer complaints are used as a method to initiate improvements
CR11: External customer satisfaction is regularly measured
CR12: Customers are actively involved in Design and improvement of firm's products & Services
CR13: Climate of cooperation exists with customers
CR14: Customers are involved in Strategic Planning

Factor 8: <u>Product Quality</u> (PQ)

PQ1: Improved overall Product Quality
PQ2: Reduced Variances in Manufactured Products (More Consistency in outputs)
PQ3: Reduced Product defects
PQ4: Continuous control and improved key processes
PQ5: Improved Product performance & Reliability
PQ6: Improvement in Perceived Product Quality by customers
PQ7: Reduction in Scrap
PQ8: Reduction in Rework
PQ9: Improved Individual Process Performance

Factor 9: <u>Service Quality</u> (SQ)

Improvements in supplier services

SS1: Reduced Delivery lead time of purchased materials
SS2: Reduction in Incoming products inspection
SS3: Assistance is provided to suppliers in overcoming problems
SS4: Reduction in rejection of parts received from suppliers
SS5: Effective processes in place for handling supplier problems
SS6: Reduction in Raw material inventories
SS7: Increase in raw material inventory turnover

Improvements in customer services

CS1: Effective processes are in place for handling customer complaints.
CS2: Customer complaints have decreased
CS3: Increase in Customer Profitability
CS4: Every employee is willing to take initiative to solve customers' problems
CS5: Employees can solve the customers' problems well and rapidly
CS6: Customers' inquiries are answered immediately
CS7: Reduced Delivery lead-time of finished products/services to customer
CS8: Customers' problems are resolved to their satisfaction.

Improvements in customer satisfaction

CX1: Systematic goals are in place for customer satisfaction
CX2: Improvement in Perceived Product Quality by customers
CX3: Increased Customer Loyalty
CX4: Increased number of customers
CX5: Decrease in Customer Complaints
CX6: Increase in Sales
CX7: Customers are satisfied with the overall services of our company
CX8: Analysis of customer satisfaction is made

Factor 10: <u>Competitive Priorities</u> (CP)

CP1: Reduced Cost of Quality
CP2: Reduced Unit Production Costs
CP3: Improved Product Delivery performance
CP4: Improved Customer Satisfaction
CP5: Improved Product Volume Flexibility
CP6: Improved Product Variety Flexibility

Factor 11: <u>Business Performance</u> (BP)

BP1: Increased Profits
BP2: Growth in Market Share
BP3: Growth in Annual Sales
BP4: Increased return on Investment
BP5: Increased throughput
BP6: Increased Cash flow