2010-05-04

Determinants of Success in ISO 9000 Implementation

Michael A. Bell
University of Miami, bellma2@email.phoenix.edu

UNIVERSITY OF MIAMI

DETERMINANTS OF SUCCESS IN ISO 9000 IMPLEMENTATION

By

Michael Albert Bell

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

May 2011

UNIVERSITY OF MIAMI

A dissertation submitted in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

DETERMINANTS OF SUCCESS IN ISO 9000 IMPLEMENTATION

Michael Albert Bell

Approved:

_____ Vincent K. Omachonu, Ph.D. Associate Professor of Industrial Engineering	_____ Terri A. Scandura, Ph.D. Dean of the Graduate School
_____ Shihab S. Asfour, Ph.D. Professor of Industrial Engineering	_____ Dingxi Qiu, Ph.D. Assistant Professor of Industrial Engineering
_____ Moiez A. Tapia, Ph.D. Professor of Electrical and Computer Engineering	

BELL, MICHAEL (Ph.D., Industrial Engineering)
Determinants of Success in ISO 9000 Implementation (May 2011)

Abstract of a dissertation at the University of Miami

Dissertation supervised by Professor Vincent K. Omachonu
No. of pages in text. (83)

The management of quality is a consideration in all industries. The ISO 9000 standard defines a management system framework which includes the necessary and sufficient elements for the systematic management of quality. Some organizations experience positive results from implementing an ISO 9000 based quality management system while others do not. Given its widespread use and the economic implications of ineffective implementation, this study analyzes the implementation process steps, the performance of system elements after certification and organization performance metrics. The methodology combines publicly available financial data and survey results to characterize the determinants of success for ISO 9000 quality management system implementation.

DEDICATION

This dissertation is dedicated to Eurael E. Bell Jr., whose memory encouraged and inspired me to "*Endeavour to Think Well.*"

ACKNOWLEDGMENTS

I would like to express my appreciation to my advisor Dr. Vincent K. Omachonu. His help and advice are major components of my successful completion of this work. I thank all of my committee members: Dr. Shihab Asfour, Dr. Moiez Tapia, and Dr. Dingxi Qiu for their advice and guidance. In addition, I am grateful for my family, friends and everyone who encouraged me along this journey. I also would like to thank my colleagues at the Kennedy Space Center who supported my doctoral studies.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

The management of quality and quality control is a consideration in all industries. Hardware production, software production, service industries, education, and government are all concerned with ensuring that their desired product or service is supplied in a manner that consistently conforms to requirements. Quality is defined as "the degree to which a set of inherent characteristics fulfills requirements" in the ANSI/ISO 9000-2000 Quality Management Systems – Fundamentals and Vocabulary standard (ASQ, 2000).

The quality control and quality assurance movement in the U.S. has its roots in the works of the quality pioneers: Joseph M. Juran, W. Edwards Demming, Walter A. Sherhart, Armand Feigenbaum, and Phillip B. Crosby (Burrill & Ledolter, 1999). Each of these pioneers provided foundational building blocks for a systematic method to focus on quality. As the quality consulting field developed, consultants have advocated for management systems as enablers of product quality. Management systems can be thought of as the framework of processes and procedures used to ensure that an organization fulfills its objectives.

History of Quality

The modern quality movement in the U.S. has its roots in the creation of assembly lines to produce automobiles. Prior to the assembly line, an individual craftsman that created an entire product from start to finish had ownership of the product's quality and received direct feedback on its suitability. However, subdividing the production of products into manageable segments for assembly necessitated systematic quality control over the entire production system. In the early 1900's, Fredrick Taylor developed the scientific management theory that focused on time and motion studies. This is considered

an early attempt to systematically managing quality. Taylor's work on efficient production with minimal waste, in part, led to Walter Shewhart's work in the area of statistical process control. Shewhart was part of a team working to improve quality in Western Electric's inspection engineering department at Bell Laboratories. Statistical process control (SPC) is the application of statistics to manage processes with the end result being product that meets the customer specifications (Wilcox, 2004). W. Edwards Deming worked similarly with statistical sampling to improve quality and also emphasized the interaction of management with workers to produce quality products as a key component of the production system. Joseph Juran expanded the tool set available for producing quality products and managing organization-wide quality by introducing the Pareto Principle as an application of statistics to prioritizing process improvements. Philip Crosby popularized the Cost of Quality concept. This theory said that the cost associated with not managing the quality of products was actually higher than the cost of a systematic method to make the product conform to the customer's requirements. In response to global competition, U.S. companies began a concerted effort to embrace systematic quality improvement and embraced Total Quality Management (TQM). TQM is a holistic business management methodology that aligns the activities of all employees in an organization with the common focus of customer satisfaction to be achieved through continuous improvement in the quality of all activities/processes, goods, and services (Burrill & Ledolter, 1999).

Efforts to better management of the production process along with the availability of modern computers lead to the introduction of Material Requirement Planning (MRP) to enhance the management of the production system. Eventually the entire supply chain

system inclusive of external suppliers was considered part of the scope of the quality management system. The Just In Time (JIT) manufacturing philosophy built around the idea of low inventory to improve visibility of product quality led to shop floor delivery of raw material and pulling production through the factory when it was needed based on available capacity. This concept was imported to the U.S. from the Japanese automobile manufacturer Toyota (Schonberger, 1982). Eli Goldratt's book "Theory of Constraints" further emphasized the process approach and that capacity balanced production processes deliver quality products by reducing over production and the resulting waste (Goldratt, 1994). Goldratt's method was to identify the constraints and either eliminate them or manage around them. His contribution to quality management systems was to consider throughput, operating costs, sales, and efficiency together instead of looking at each of them in isolation.

The Malcolm Baldrige National Quality Improvement Act of 1987 was enacted to recognize U.S. companies that are managing their organization with seven specific quality system best practices and are achieving results with those practices (Baldrige National Quality Program, 2009). The award process was designed to stimulate U.S. companies to improve quality. Today there are at least 90 quality and business excellence awards in at least 75 countries around the world (Djerdjouri, 2004). A popular improvement methodology called Six Sigma has evolved from the Total Quality Management movement. It is an analytical approach to quality improvement through process yield improvement. Six Sigma process improvements must quantify the financial impact of their improvement prior to initiating the implementation of the process change. A related effort is the Lean Initiative, which seeks to deliver better products by

eliminating process waste. Lean Six Sigma takes the best of both initiatives to optimize the process for meeting the customer's requirements. The evolution of quality initiatives is depicted in the figure 1.1.

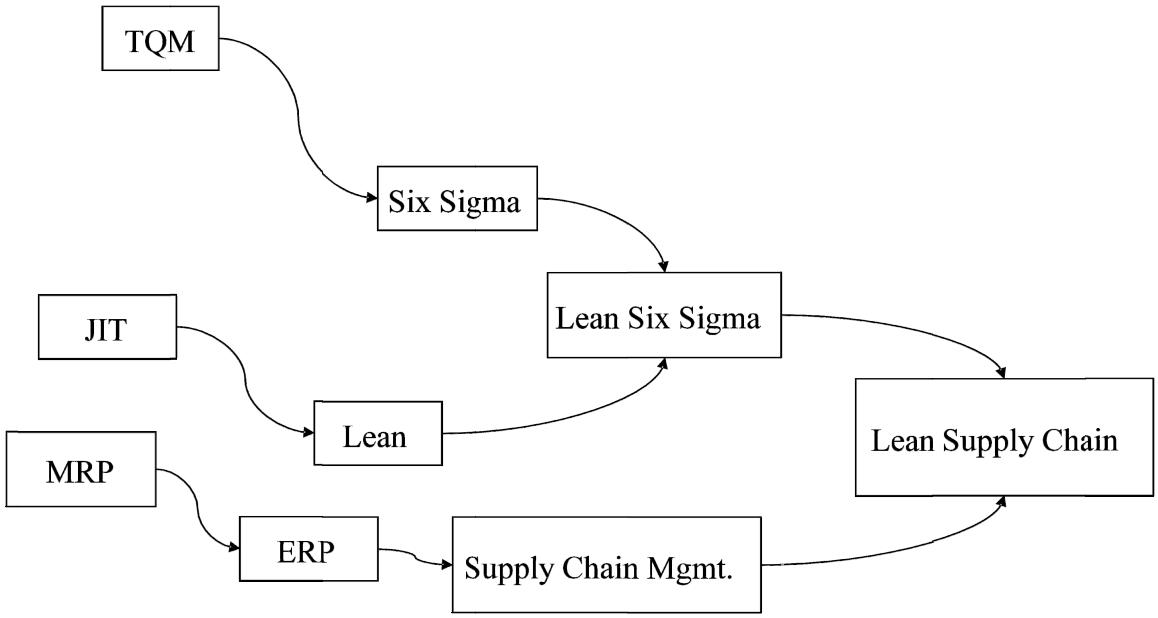

Figure 1. 1 Evolution of Quality Initiatives

Why a Management System?

A quality management system is the framework of processes used to ensure that an organization fulfills its objectives. To effectively manage an organization, a mechanism is required to document policy and control changes. In addition, an organization also needs some method for defining processes and documenting how work gets done. A third common function in managing an organization is a provision for reviewing progress and maintaining records of activities that have been completed. These functions together constitute the system the organization uses to manage even if the elements are not packaged together into a formalized management system.

The ISO 9000 Standard contains a minimum set of elements that are considered necessary for a quality management system. ISO 9000 is a series of five international

standards published in 1987 by the International Organization for Standardization (ISO) based in Geneva, Switzerland (Baldrige National Quality Program, 2009). The system is aimed at achieving customer satisfaction with the product or service by preventing nonconformity to the customer's requirements and is recognized by more than 161 countries. As previously stated, a product that conforms to customer requirements is considered a quality product.

Industry Applicability

Even though some specific ISO 9000 requirements do not seem to be appropriate for all industries, the ISO 9000 standard is applicable across all industries because the requirements of the standard are designed to help an organization satisfy its customers and the ISO 9000 system elements are the basic requirements needed for a system to manage quality.

Ninety seven industry areas are identified in the North American Industry Classification System, (NAICS). Selected major industries from the NAIC system are;

- Agricultural & Farming
- Chemical Products
- Real Estate
- Research
- Oil & Gas
- Computer & Electronics Production
- Educational Services
- Construction
- Retailers
- Ground & Air Passenger Transport
- Health Care
- Food And Beverage Production
- Publishing
- Performing Arts
- Religious
- Textile & Apparel
- Telecommunications
- Justice & Public Safety
- Professional Services

These industries can be categorized in several ways such as product or service, profit or non-profit, continuous production or discrete product, high volume or low volume, long or short process duration, and high technology or low technology. Some industries have a production processing time of days versus months of cycle time. The

pharmaceutical industry can have a long incubation time. In all of these industries, a system is needed to manage quality.

The ISO 9000 standard was initially designed with a decidedly manufacturing influence. The 1987 version of the standard contained twenty elements that were derived from the British quality standard BS 5750. The standard was later embraced by service organizations and at one point was thought to be applicable to all types of industries around the world. Industries that have a prominent supplier-subcontractor relationship with a discrete product hand-off were an especially good fit for this version of the standard. Elements of the standard focus on supplier's data, customer supplied products and managing quality across the supply chain. Industries that have a distributed supply chain or those that tend to be multinational with segmented production are amenable to ISO 9000 certification.

Even though some specific requirements do not seem to be appropriate for all industries, the standard is applicable across all industries because the requirements of the standard are to be interpreted to help satisfy customers. Customer focus is an aspect of the standard that heavily influences service industries.

Some specific requirements that do not seem to be appropriate for all industries are; internal audits, quality system manual and process documentation. The internal audits can be seen as a waste of time activity that is done to maintain certification in industries that already have external regulating bodies. The requirement to create an overarching manual for the quality system can also be seen as something that is done only to be shown to ISO 9000 auditors when organizations often have business plans, strategic plans, policy manuals or annual budget documents that are used by executives to

run their organization. However, the task of compiling a manual that describes the organization's quality management system can help to unify the existing quality management elements into an orchestrated system. In addition, the requirements for documentation can be seen as excessive in industries where skilled and experienced knowledge workers are forced to document trivial details. Knowledge oriented industries without a physical product still need a system for managing quality. In a hospital, the patient is part of the production process and is also the end product. ISO 9000 implementers may have difficulty mapping the production oriented requirements to the healthcare industry.

Specific industries have determined that the general requirements of the standard do not cover some important aspects needed to maintain quality in their industry. Industry specific standards such as; AS9100 for the Aerospace industry, TL 9000 for the Telecommunications industry, TS 16949 for the Automotive Industry, ISO 13485 for Medical Devices are examples of industry specific quality management system standards. These standards are generally used in addition to ISO 9001 certification.

Although some specific requirements do not seem to be appropriate for all industries, the ISO 9000 quality management system standard is applicable across all industries for two main reasons. First, the requirements of the standard are designed to help satisfy customers. But most importantly, ISO 9000 contains the basic requirements for a management system that are needed to manage quality.

Certification Administration

Organizations may elect first, second, or third party certification. First party certification involves a firm auditing itself against ISO 9001 standards. Second party certification means that a customer audits its supplier. Third party certification involves a "qualified" national or international standards or certifying agency serving as the auditor. The International Accreditation Forum (IAF) in conjunction with accreditation bodies in each country control the certification process (Gyani, 2007).

The ISO governing body in Geneva, Switzerland periodically reviews all of its international standards and entertains proposals for changes. The ISO 9000 standard is on a four-year cycle, and technical representatives from around the world work to revise it to keep it current.

Management System Frameworks

The following are examples of management systems or frameworks in common use: ISO 9000 Quality Management System standard, the Malcolm Baldridge National Quality Award criteria, the Capability Maturity Model, Six Sigma, and Total Quality Management (TQM) or the Plan-Do-Check-Act cycle. According to researchers, the aforementioned quality management frameworks have yielded various degrees of success for organizations that have implemented them. Many researchers have focused on the effects of TQM or other quality initiatives. However ISO 9000 emerged as the de facto worldwide standard for quality system certification (Brisco et al, 2005).

The cost and the benefits of implementing a quality management framework can be substantial. In the 1990s, many organizations demanded that their suppliers have a certified quality management system despite the financial and time considerations involved. In 1997, the typical cost of preparing a medium-sized U.S. firm for ISO 9000

certification was $250,000 (Simmons & White, 1999), yet a survey of 1,700 certified firms in the U.S. and Canada identified that firms reported average savings of $179,000 per year from certification (Buttle, 1997). Obtaining management system certification can take up to a year of preparation.

Given its widespread use and economic implications for industry, the ISO 9000 management system framework must be researched to understand which aspects are most beneficial to organizations and to identify the best ways to measure the benefits derived from adopting a management system framework. The ISO standards process is designed to collect input and periodically revise standards to maintain their relevancy. Studying the implementation process will lead to new insights, which may help to evolve future versions of ISO 9000. In addition, as companies emerge from the global financial crisis of 2008, issues related to globalism and global competiveness are important to study.

CHAPTER 2: REVIEW OF LITERATURE

This section contains a review of the current ideas from previous research in the area of ISO 9000 quality management system effectiveness. This review will provide the foundation and framework for developing new understanding and knowledge of the process of effective management system implementation. A significant amount of research and study have taken place in the area of quality management systems. This review of the literature will focus in the following major areas:

- Total Quality Management and ISO 9000
- Quality Management System Related Dissertations
- Environmental Factors Effecting Quality Management Systems
- Small Businesses and Quality Management
- Industry-Specific Research
- Organizational Performance Indictors of Quality Management

Total Quality Management and ISO 9000 Controversy

Many believe that ISO 9000 certification can be viewed as a step on the road to total quality. Van den Heuvel discusses six approaches to defining quality in an article exploring the payoff of ISO 9000 certification (van den Heuvel, Boger, Does, van Dijk, & Berg, 2006). They are:

- Quality is an innate excellence and cannot be defined or measured.
- Quality reflects the presence or absence of measurable product attributes.
- Highest quality goods are those that best satisfy customer's preferences.
- Quality is the conformance to requirements.

- Quality product provides performance at an acceptable price.
- Quality is the degree to which customers wishes are met.

The variety of these approaches illustrates the diversity of thought around quality and quality management systems. Professor Gongxu Zhang (1995), a quality management researcher states that the focus of the changes incorporated in the 1994 revision of the ISO 9000 standard are to enhance the process focus. Zhang promotes the idea that ISO 9000 certifcation is just the foundation for true quality. The use of Statistical Process Control Diagnosis and Adjustment (SPCDA) enhances the focus on quality by understanding the process used to produce the organization's product or service and making adjustments to the process to improve it.

Research to evaluate different quality management frameworks has been done by Carl Johannsen as part of the 1993 – 1994 Nordic Quality Management Project (Johannsen, 1996). According to Nancy Tague in "Managing Service Quality," the initial intent of ISO 9000 quality management system certifcation was for organizations to gain confidence in the quality management system of their suppliers (Tague, 1994). However, V.N. McLachlan, a quality consultant, writes that the critics against ISO 9000 certification are misguided in that they are interpreting the implementation of ISO 9000 incorrectly. ISO 9000 is not a product quality standard but a standard for quality management. ISO 9000 was not meant to take the place of any industry-specific product quality standard.

Criticisms of ISO 9000 Certification

In a 2003 survey, quality professionals were asked whether the ISO 9000 standard has lived up to its expectations. Overall 42% perceived ISO 9000 as "a system with flaws

that is taking us in the right direction" while 40% said "the system provides a good basis for total quality management" (Douglas, Coleman, & Oddy, 2003). Critics of the standard contend that an organization can become certified and still produce poor quality output. Some point to specific companies that are certified and do not seem to deserve it. This is seen as a weakness of the accreditation process. A common negative perception is "that registration to a standard has no relationship with business improvement." Other criticisms of certification identified were that "quality by inspection is not quality" and "certification is dependent on the assessors' definition of quality." Some critics of the older versions of standard have said that it has a narrow focus emphasizing conformance to specifications and does not address customer satisfaction achievements (Johannsen, 1996). A third criticism is that the ISO 9000 standard is jargon ridden. It is promoted as a universal standard that is applicable to any organization; however, some of the terminology needs to be translated for non-manufacturing organizations. The scope of TQM is much broader than ISO 9000 as a management system framework. A criterion that Johannsen uses to judge the usefulness of a quality management system framework is its comprehensiveness and the reliability of the assessment. A critical feature of a reliable assessment model is that two organizations with the same characteristics should achieve the same assessment. Finally, quality consultants might be overselling reducing waste and reducing costs as the direct benefits of ISO 9000 certification.

Quantifying the benefit of quality management in healthcare was undertaken in a study (van den Heuvel, Boger, Does, van Dijk, & Berg, 2006). The health care industry continues to face challenges due to poorly designed processes. The issues of costs and waste have been highlighted in this industry for a number of years. Two different

components of a quality management system are quality control and quality improvement. The ISO 9000 standard provides the structure for these activities but does not guarantee excellence in these areas. Focusing on cost containment without an effective quality assurance system can endanger quality; this is an argument for a systems approach to managing quality. Experiences from the Nordic quality management project suggest that two important roles for management of successful implementation are disturbance handler and resource allocator. It is difficult to capture the cost of ISO 9000 implementation due to the costs being hidden in other budgets or absorbed in overhead costs. This complicates the calculation of a payback period or return on investment for ISO 9000 certification.

McLachlan (1996) highlights four ISO 9000 requirements that seem to cause difficulty for implemetors: Records, Training, Internal Audits, and Documentation. In a proper ISO 9000 implemetation, these elements can be tailored for the needs of each organization and still meet the intent of the standard. The implementation process should be based on awareness of the benefits of process focus (Tague, 1994). According to Tague, several sessions over an extended period of time are needed to make this happen. Staff resentment and resistance can derail the implementation effort if ISO 9000 certification is perceived as non-value added. Understanding that organizations accomplish their work through a network of processes would enable organization's to realize the synergy between ISO 9000 and total quality. The key is understanding the interfaces and processes that cut across departments. Quality is best achieved by the simultaneous application of product quality standards and quality system standards

involving a systems and process approach (van den Heuvel, Boger, Does, van Dijk, & Berg, 2006).

Quality Management System Related Dissertations

In a review of eight doctoral dissertations related to the effectiveness of management systems (see Table 2.1), two researchers, Morris (2003) and Terlaak (2002), concluded that ISO 9000 certification does not have a positive impact on an organization's financial measures. Morris cited the existence of other systems, motivation for obtaining certification, and differences in organization size as possible influencing factors. Terlaak's focus on both ISO 9000 and ISO 14000, which is an environmental management system standard, might explain why the study found no evidence of operational improvement.

Five dissertation researchers concluded that there is a positive relationship between establishing an ISO 9000 based quality management system and an organization's performance (Skrabec, 1999; Paden, 2003; Laframboise, 2002; Han, 2000; and Mumma, 2000. Therefore, the question "Does ISO 9000 management system certification have a positive effect on business performance?" is no longer a relevant question. More relevant questions are:

1. What are the best ways to implement ISO 9000?
2. Which aspects of the ISO 9000 standard are correlated to the highest improvement in business results?
3. Which organizational processes benefit most from systemization (documentation, corrective action, etc.)?

The aforementioned doctoral studies did not focus on specific elements of the standard; rather, they studied the absence or presence of system certification as whole. In a doctoral dissertation studying Fortune 500 companies, Arbuckle compared the performance of organizations before and after certification (Arbuckle, 2004). The results of that study showed a statistically significant improvement in sales after ISO 9000 certification of a business' management system while return on assets dropped after firms became ISO 9000 certified. In a British study, consumers perceived firms that had ISO 9000 certified management systems as providing higher quality products (Tannock & Henry, 2004). That study might provide an explanation for Arbuckle's mixed findings on the impact of ISO 9000 certification.

Table 2.1 Doctoral Research on the Effectiveness of Management System Certification

Author	Focus Area	ISO 9000 Impact
Arbuckle, **Indiana State University**, 2004	Changes in selected measures of performance before and after certification	Mixed
Han, **University of Rhode Island**, 2000	The relationships between and among ISO 9000 registration efforts, TQM practices, organizational competitiveness, customer satisfaction, and business performance	Positive
Laframboise, **Concordia University (Canada)**, 2002	Various quality initiatives' effect on perceived performance excellence	Positive
Morris, **Texas Tech University**, 2003	Financial performance of ISO 9000 certified firms in the electronics industry versus firms that were not ISO 9000 certified	Not positive
Mumma, **Mississippi State University**, 2000	Impact of ISO 9000 standards on U.S. agribusiness and trade	Positive
Paden, **Northcentral University**, 2003	Use of the ISO 9001 quality management system within the North	Positive

Author	Focus Area	ISO 9000 Impact
	American chemical industry	
Skrabec, **The University of Toledo**, 1999	The underlying theoretical framework for ISO 9000 as a Quality Assurance system and the performance resulting from implementation of such a system	Positive
Terlaak, **University of California, Santa Barbara**, 2002	Operational improvement for both ISO 9000 and ISO 14000	Not positive

Environmental Factors

Some organizations experience positive results from implementing an ISO 9000 based quality management system, and others do not. Some of the causes for differences in performance results of ISO 9000 certification have been identified as follows:

1. Industry (Heras et al, 2002), (Morris, 2003)
2. Company size (Haversjo, 2000), (Morris, 2003), (Corbett et al, 2005)
3. Population differences of country studied (Haversjo, 2000), (Terrak, 2002)
4. Implementation methodology (Powers, 2003)
5. Management commitment (Quazi & Padibjo, 1998)
6. Motivation for seeking certification (Williams, 2003; Terrak, 2002; Singels et al, 2000; Morris, 2003)
7. Pre-existing quality management maturity level/quality system (Knight, 1997), (Briscoe, Fawcett & Todd, 2005; Paden, 2003; Morris, 2003)
8. Employee perception of quality (Harrison, 2000)
9. Differential usage of quality management system characteristics (Dixon, 1996)

The first four factors—industry, company size, country and implementation method—can be easily identified and quantified. A definition of corporate culture is the set of shared understandings of how the world works that is held by a corporation and influences and directs management performance (Harris, 1987). Factors 4 – 9 could be classified as cultural factors and are more difficult to quantify.

Small Business Focus

A survey of small businesses in Finland and a case study of a small business in Taiwan concluded that the benefit of ISO 9000 quality management system certification is marginal (Sun & Cheng, 2002 and Bendell & Boulter, 2004). In another study, small businesses in more dynamic product environments, such as the computer electronics industry, were shown to benefit more from management system frameworks than other types of small businesses (Briscoe, Fawcett & Todd, 2005). Bendell and Boulter suggest that the systemization of basic organizational processes may enhance small business' capability to increase capacity and grow. The applicability of a management system framework to firms with a less complex production process is discussed by Bravener (Braver, 2005) in an article concerning the AS9003 standard for aerospace subcontractors. Braverner contends that a quality inspection and test system is different from a full-scale quality management system and that a full-scale quality management system is not always warranted for smaller organizations. In small businesses, meetings are organized spontaneously when there is a need, and information is spread to everyone easily. Every employee's contribution is important to reach a high-quality level. Therefore, employees might feel more engaged and interested in changes (Gustafsson et al, 2001).

Current research shows that small businesses grow more rapidly, create more jobs, and are vital to the economy (Bristoe, Fawcett, & Todd, 2005). At the end of the first quarter of 2005, there were 4.9 million firms in the private sector of the U.S. economy. Firms with fewer than 500 employees accounted for 99.6 percent of all firms and 55.8 percent of total employment (http://www.bls.gov/bdm/). The number of larger businesses outsourcing and subcontracting to small business is increasing so that the larger business can focus on their core competencies, augment capacity when needed, and take advantage of lower overhead costs. Many Fortune 500 companies have given employees incentives to leave and start their own businesses A study co-produced by McGraw-Hill and Dun & Bradstreet showed that about 25% of all ISO 9000-registered companies have less than 150 employees, and 29% of registered companies have between 150 and 500 employees (Callahan & Schnoll, 1997).

In another study, small businesses in more dynamic product environments, such as in the computer electronics industry, were shown to benefit more from management system frameworks than other small businesses (Briscoe, Fawcett, & Todd, 2005). Finally, Chow-Chua (2003) and Morris (2006) investigated the benefits of ISO 9000 certification and suggest that the effect of company size is a confounding variable needing additional research. Sun's (2004) research showed that small businesses have less success than large businesses when implementing ISO 9000.

Electronics Industry

The use of electronics and electronic components is increasing exponentially in the aerospace, automotive, and telecommunications industries (Gordon, 2006). Global consumer electronics markets are evolving rapidly, with many products being rendered

obsolete by recent technological advances. The digitalization of consumer electronics has led to the convergence of technologies between previously distinct market segments. By 2010, the Global Consumer Electronics Industry market value is forecast to increase 22.6% from the 2005 level. Drivers of market growth are likely to include continuous innovation by manufacturers (DataMonitor, 2006).

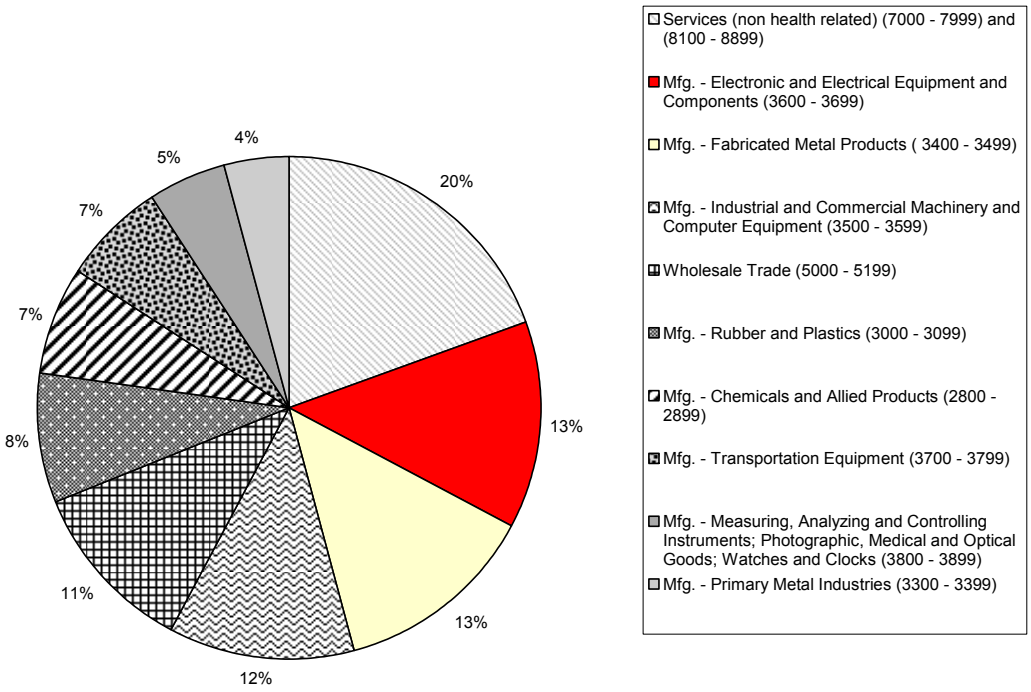

Figure 2.2. Top 10 Manufacturing Certification Industry Sectors.

Derivatives of ISO 9000 or industry-specific standards include AS9100 for Aerospace, TL for Telecommunications, TS for Automotive, 13485 for Medical, ISO 14001 for environmental concerns, and OHSAS 18001 for health and safety. A recent Delphi opinion survey of quality auditors predicts the trend toward developing industry-specific standards to continue into the future (Bandyopadhyay, 2005). No specific standard exists in the electronics technology sector. Figure 2.2 shows the relative distribution of ISO

9000 manufacturing industry certifications in the United States by industry in 2004. The electronics sector is the second most popular industry. Studies of financial performance of certified firms in the electronics industry have yielded conflicting results. Corbett (Corbett et al, 2005) reported significantly better financial performance for certified firms while Morris' research (2006) found no support for financial improvement after ISO 9000 certification of companies in the electronics industry. Both studies indicate differences in results based on the size of the company.

Organizational Performance Indicators

Various performance measures have been used to quantify the impact of certification on organizational performance. Table 2.2 summarizes some indicators that have been used. It can be seen from the table that Return On Assets, (ROA) and Sales Increase, Market Share have been used most frequently.

$$ROA = \text{Net Profit} / \text{Total Assets}$$

Return On Equity is considered one of the four key financial ratios used to measure earnings performance; however, equity can be difficult to parse out to divisions of a large corporation, so Return On Assets more is commonly used (Kristy, 1994).

Table 2.2 Performance Indicators Used to Quantify the Impact of ISO 9000

Author	Year	**Return on Assets**	Sales Increase	Market Share	Debt to Equity Ratio	Earnings per share	Net Profit Margin	Operating Costs	Profit margin on sales	Return on Capital	Return on common Equity	Return on Sales	Sales per Employee	Stock Price
Marquadt	1992							X						
Ebrahimpour	1997			X										
Quazi & Padibjo	1998		X											
Beattie & Sohal	1999	X			X	X			X		X			
Casadesus & Gimenz	2000	X										X	X	
Haversjo	2000									X				
Singel et al	2000		X	X			X							
Aarts & Vos	2001													X
Heras et al	2002	X												

Return On Assets can be used to characterize the efficiency of an organization. This number tells "what the company can do with what it's got," i.e., how many dollars of profits it can achieve for each dollar of assets the company controls (Sun, 2000). An organization with less rework and scrap is expected to have financial performance superior to organizations with higher levels of rework resulting from out-of-control and poorly documented processes. Therefore, an organization with an effective management system would be expected to be more efficient with its resources than organizations without effective management systems.

Mann and Kehoe (1994) examined the elements of total quality management that impact business success. Their research highlighted both procedures and a formal feedback system as two key components. Tsiotras and Gotzamani (1996) emphasize periodic review, formal corrective actions, and process focus as key elements of quality management systems that impact organizational performance. Carlsson and Carlsson (1996) identified better processes and better customer relations as benefits of

implementing ISO 9000 in Swedish companies. Lee and Palmer (1999) cite monitoring day-to-day adherence to documented procedures and understanding of the corrective action process as significant challenges.

Table 2.3 Key Quality System Elements That Impact Organizational Performance

	Mann and Kehoe 1994	Tsiostras and Gotzman 1996	Carlsson and Carlsson 1996	Lee and Palmer 1999
Documented Procedures	√			√
Formal Feedback Systems	√			
Periodic Mgt Review		√		
Formal Corrective Actions		√		√
Process Focus		√	√	
Customer Focus			√	

Figure 2.3 suggests links between the elements of the ISO 9000 quality management system standard and the commonly accepted measures of organizational performance in Table 2.3. According to Ram Charan in his book *Profitable Growth is Everyone's Business* (2004), "singles and doubles executed incrementally will result in profitable growth, but most organizations today are focusing on hitting home runs." Properly functioning management reviews as part of a quality management system will enable identification and implementation of these "singles" or incremental improvements.

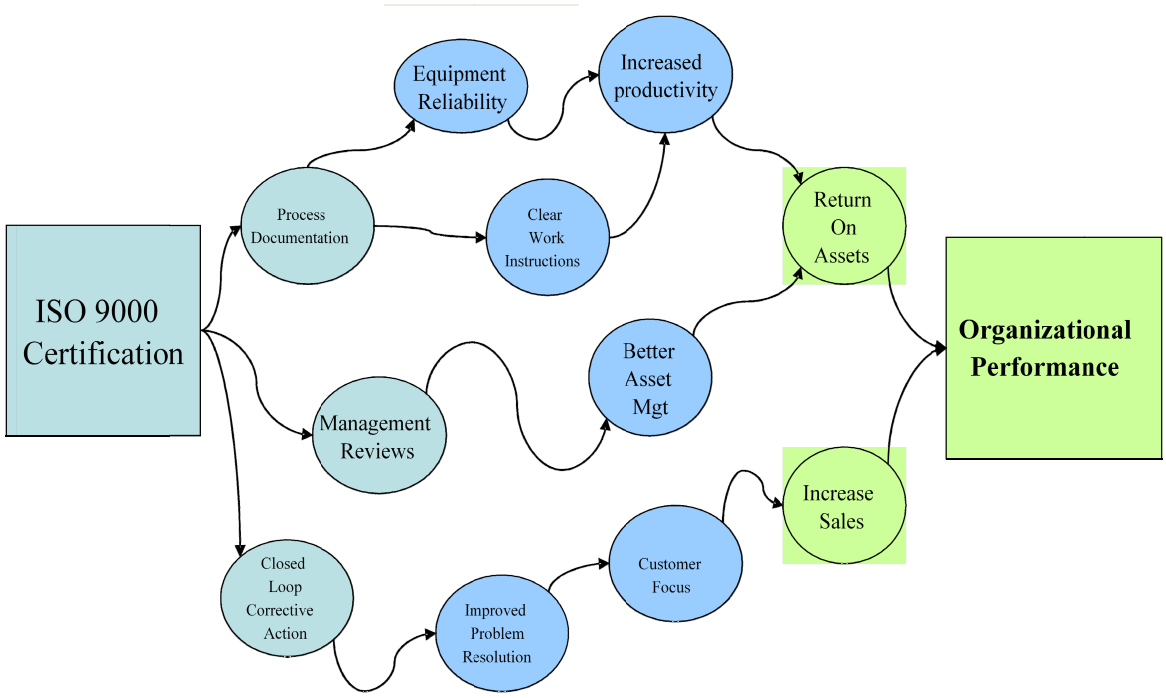

Figure 2.3 ISO 9000 Certification & Organization Performance Influence Diagram

An analysis of the factors identified in Figure 2.3 would validate the relationships.

Many studies have established a correlation between the existence of ISO 9000 certification and company performance (Heras, Casadesus, & Dick, 2002; Beattie & Sohal, 1999; Haversjo, 2000; Quazi & Padibjo, 1998; Terziovski, Samson and Dow, 1997). This research attempts to further define the link between an ISO 9000 certified management system and organizational performance by examining the specific elements of the management system standard that have the greatest impact on organizational performance so that proper emphasis can be placed on the areas that will provide highest return for the organization.

CHAPTER 3: RESEARCH METHODOLOGY

From the literature, the approaches used to study management systems have relied upon collecting data via surveys, case studies, and examination of publicly available records such as financial reports and stock price records. Studies using these methods for researching the benefits of ISO certification are cataloged in Table 3.4.

Table 3. 4 Data Collection Methods to Study The Impact Of ISO 9000 Certification

Method	Author
Structured Interviews	Hill et al, 2001
Questionnaire/Survey	Gotzamani and Tsiotras, 2002; Lee, 1995, 1998; Singles et al, 2001; Issac, Rajendren, and Anantharaman, 2004; Briscoe, Fawcett & Todd, 2005
Case Study	Hill et al, 2001; Ebrahimpour, Wither, and Hikmet, 1997
Cluster Analysis	Casadesus and Giminez, 2000
Content Analysis of Secondary Sources	Aarts and Vos, 2001; Beattie and Sohal 1999; Haversjo. 2000; Hera, Casadesus, Dick, 2002; Morris, 2006; Corbett, Montes-Sancho, and Kirsch, 2005;
Survey and Analysis of Secondary Source Data	Chow-Chua et al 2003
Survey and Interviews	Mann and Kehoe, 1994

Survey Method Strength and Criticisms

The questionnaire method was most commonly used by researchers studying this topic. Survey response return rates between 20% – 38% were commonly observed. The survey method rather than case studies or interviews was used for this research so that a significant amount of data could be collected in a timely manner. A criticism of previous studies is that differences in company sizes of the samples studied and industry differences may have been the reason the studies were inconclusive. This survey identified the industry and businesses size to control for those environmental variables.

Using the survey method, the respondents' perceptions were converted to a five-point Likert scale for analysis. A weakness of the questionnaire method is that surveys are typically sent to the person responsible for ISO certification so that some success bias might be observed (Carlsson & Carlsson, 1996). Success bias is considered to be providing overly optimistic answers as to the value of certification due to the respondent's role in implementing the quality management system. The survey instrument collected the job title of the respondents to detect if there is a significant difference in responses depending on who is responding and to identify if success bias exists.

Publicly available balance sheet data has been analyzed by other researchers to study the impact of ISO 9000 certification. Information service databases have readily available balance sheet information through the Internet. Analyzing publically available data more objectively portrays company performance based on auditable financial measures. However, some companies may employ accounting strategies to defer gains or losses or take one-time write-offs, which influence their balance sheet numbers. The balance sheet numbers can also be influenced by failed product development or marketing campaigns so that the impact of quality system certification might not always be accurately reflected on the bottom line.

Connecting Process and Outcomes

The survey instrument collected data to study the connection between the implementation process and business outcomes. Donabedian (1980) developed a framework for discussing the connection between process and outcome as they relate to quality. Research by Laponte and Rivard (2006) on the acceptance of new information

technology systems in hospitals highlighted the importance of the implementation process. In addition, there is a growing understanding that the process of implementing new systems and execution of business systems are core competencies for companies today (Faull & Flemming, 2005 and Griswold & Prenovitz, 1993). Sun's (2004) research showed that small businesses have less success than large businesses when implementing ISO 9000.

In a 1994 article titled "The Proven Path to ISO 9000 Certification," Murakami (1994) describes the steps that companies take in order to gain ISO 9000 certification for their quality management system. Based on the work of Murakami along with Smith (1994) and Jodoin (1998), the implementation process steps are identified in Table 3.5. These steps were incorporated into the survey to investigate the degree to which ISO 9000 certified organizations have followed a structured process to become certified.

Table 3.5 Steps to Implement ISO 9000

Murakami (1994)	**Smith (1994)**	**Jodoin (1998)**
• Perform an ISO assessment. • Prepare quality manual and quality policy. • Train employees in ISO 9000. • Document work instructions. • Conduct registration audit.	• Establish commitment throughout the company. • Partner with assessors. • Construct friendly draft procedures. • Conduct a pre-assessment audit. • Implement the procedures. • Conduct an internal review. • Undergo assessment.	• Get management commitment. • Employ outside consultants. • Make everyone aware of the coming change. Introduce everyone to the benefits of ISO 9000. • Create a quality manual. • Establish a workable documentation system. • Provide employees with training on the system.

This research also explored the outcomes related to specific elements of the ISO 9000 quality management system framework. The ISO 9004:2000 Standard on Quality System Improvements provides guidance for assessment of the maturity level of the performance of the quality system elements using an adjective scale to rate the system (ASQ, 2000). The quality system elements that impact business success were compiled from the literature and are shown in Table 2.3. The survey assessment tool collected data to measure the performance level of the individual elements. The mathematical relationship between the macro business performance indicator Return On Assets and the performance level of the individual quality system elements was investigated. By comparing adherence to a good process for implementing a quality management system and the outcomes of the quality system elements, a correlation analysis was conducted to provide conclusions for success with ISO 9000.

Data Collection and Data Sources

The commercial website Surveymonkey.com was used to create a pilot survey to review the wording, order of the questions, and flow of the survey. The commercial benchmarking company Benchnet.com hosted the survey for actual data collection. The data for this study was collected over a 12-week period using a survey form on the World Wide Web. Survey invitations were e-mailed to members of the Benchmarking Exchange and also placed in two consecutive issues of the Quality Digest electronic newsletter; by definition, this is a convenience sample. One-hundred-fifty responses were received. This is a relatively small number of responses compared to the number of people who received the e-mailed invitations and compared to the approximately 150,000 organizations that are ISO 9001 registered worldwide. However, Quazi and Padibjo (1998) and Chow-Chua

(2003) both used fewer survey responses to develop conclusions from their research on ISO 9000 effectiveness. Singels (2000) examined 192 organizations, and Heras, Casadesus, and Dick (2002) studied 400 companies. Studies in which a small sample size is used are not uncommon and generally are appropriate for this type of research. The number of respondents (150) and the population of ISO 9001:2000 certificates issued (951,486), result in an 8.87 confidence interval at the 95% confidence level.

Survey Instrument

The survey instrument consisted of 15 questions separated into four sections. Before the first set of questions, the company name and city were requested to assist with verifying the certification status of the respondent. Also, the respondent's title and department name were collected along with the number of employees in the organization. A report of the survey findings was offered as an incentive for completing the survey so the respondent's name and e-mail address were requested.

The first section concerned the certification status, other quality initiatives undertaken by the organization, and motivation for seeking certification. By asking which sections of the standard were excluded from certification, a profile of the organization was developed in terms of the scope of quality management system and their focus on domestic or international markets. The second section focused on the process used for certification. Nine activities were presented as potential components to their path to certification. The respondents provided data and how much emphasis was placed on these activities or if the activities were simply not used at all. Unstructured free text comments were also collected about their experience with the certification process. The third section focused on the performance of the quality management system in five key areas.

Respondents checked boxes on a scale to indicate their system's performance. An area was provided for text comments about the system performance. The last section of the survey showed 17 performance measures on the screen and asked respondents to indicate whether each measure was an important measure, somewhat useful, or not useful at all for assessing organizational performance. At the end of the survey, the respondents selected their industry code from a drop-down list. The 2002 North American Industry Classification System (NIACS) categories were used.

Data Analysis Methodology

The raw data from the web survey was downloaded the into a Microsoft Excel file for analysis. Basic descriptive statistics of each variable representing implementation steps were examined to provide quantitative insight into the implementation process. The variables representing the management system elements will be examined in the same way. MINITAB© software was used to analyze the correlations between the implementation step variables and the management system element variables. Combinations and subsets of the implementation variables were tested for their effect on the management system element variables.

CHAPTER 4: RESULTS AND DISCUSSION

The analysis of results is focused on four sections: the implementation activities, system outcomes, predictions, and performance metrics.

Respondent Demographics

In Chapter 2, environmental factors that might impact this research were identified. The respondent demographics show a balance across the factors that should negate any bias or undo influence by a single factor. The responses were from 63% small business and 37% large business, nine years or less (53%), 10 years or more (47%), and internal (52%) versus external (48%) reasons for seeking certification. The data set should not be biased by an overrepresentation of respondents in any one of these categories. In addition, the data also represents a mix of working level (65%) and senior managers (35%) respondents as well as quality system personnel (55%) and other respondents (45%). In the sample, 58% were from manufacturing industries versus 42% for all others. Finally, the survey represents 70% respondents from the United States and 30% from outside the United States.

Approximately 65% of the respondents also implemented Continuous Improvement, and nearly 40% also implemented TQM, SPC Lean, and Six Sigma. However, most (82%) had not applied for quality awards. The survey responses represent a balance from the above categories but cannot be said to be a stratified sample of the population because the demographics of the entire population are not known. No trends were detected that would cause concern.

Data Analysis

Implementation Activities Data

The survey respondents rated their use of the implementation activities on a scale with a descriptor starting from "not done" up to "very large degree." Figure 4.4 shows the implementation activities question of the survey and the scale used.

To what degree were the following items implemented as part of your ISO 9000 certification effort? Place a check (√) in column that best describes your implementation experience.

	Not Done	Very Small Degree				Very Large Degree
	0	1	2	3	4	5

Figure 4.4 Implementation Activities Survey Scale

The adjective descriptors correspond to numerical values, and the average ratings were evaluated.

Implementation Data Reliability

Internal consistency using Cronbach's alpha coefficient is calculated using the formula in figure 4.5 to see how reliable the implementation data is with respect to errors built into administration of the survey instrument (Gliem, 2003).

Figure 4.5 Internal Consistency Reliability Coefficient Alpha Equation

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum s_i^2}{s_t^2}\right]$$

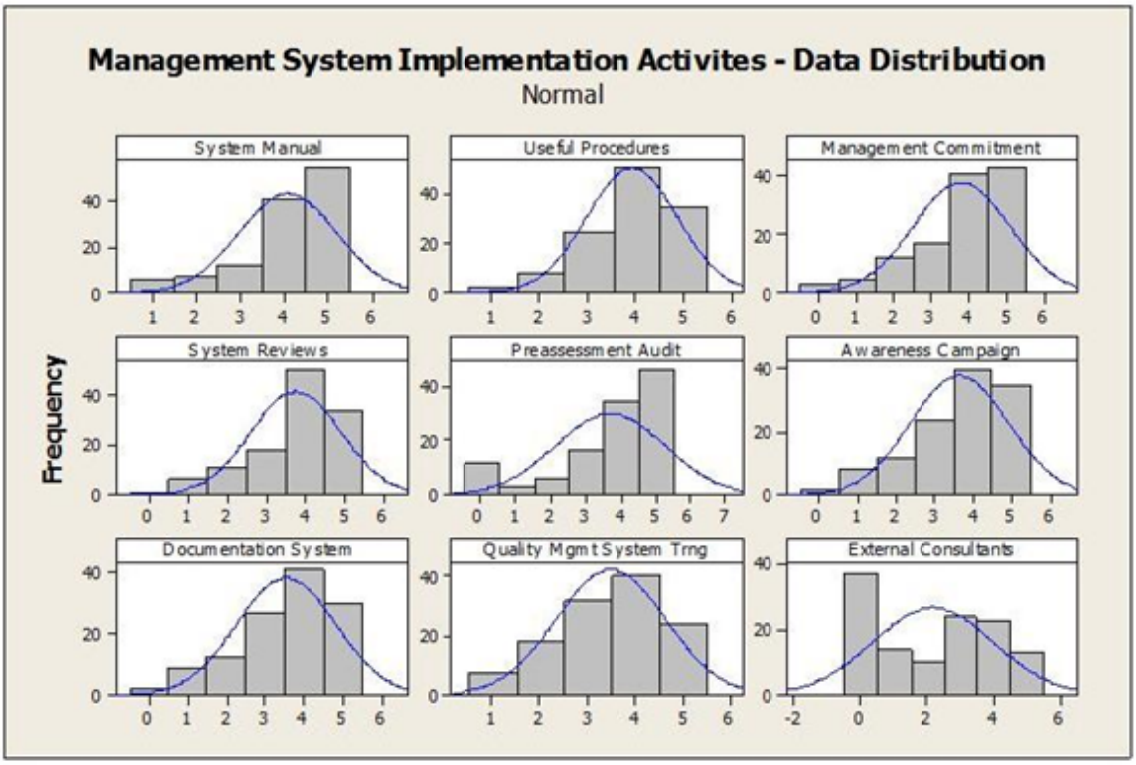

Figure 4. 6 Implementation Activity Distribution Data

The reliability estimate of 0.790 indicates that the errors due to administration of the survey are small enough so that we can confidently use the data from this assessment to understand the use of various activities for quality management system implementation.

Figure 4.6 shows the respondent ratings data distribution. The histograms are overlaid with a normal curve for comparison; these responses are clearly non-normal since they are on a Likert scale and are discrete.

The ratings histograms are displayed in order sorted from the highest usage to the lowest usage. The activity with the highest use based on mean and the number of "very large degree" responses was System Manual. A system manual is required for certification, and no survey respondents indicated that it was not done. Some respondents did indicate that it was only done to a very small degree. The second-highest average response was the creation of useful procedures. Eighty-one percent of respondents said

this was done to a large or very large degree. Table 4.6 shows that the standard deviation for this activity was the smallest of all implementation responses, which might indicate a more universal understanding of the concept.

The examination of the data concerning the ISO 9000 implementation activities indicated that two implementation activities were most often excluded: the use of external consultants and conducting a pre-assessment audit. The use of external consultants had the largest variation in rating from respondents.

Table 4. 6 Use of ISO 900 Implementation Activities

	System Manual	Useful Proced.	Mgt. Comm.	System Reviews	Pre Audit	Aware Camp.	Useful Doc. System	System Training	External Consult.
Mean	4.10	3.90	3.80	3.77	3.64	3.62	3.55	3.46	2.17
Median	4	4	4	4	4	4	4	4	2
Mode	5	4	5	4	5	4	4	4	0
Std	1.11	0.95	1.27	1.15	1.60	1.27	1.27	1.14	**1.81**

Table 4.7 Implementation Activities – Sign Test on Median Differences and P-values

Implementation Activity	***P***	***Median***
External Consultants	0	2
System Training	0.0001	4
Documentation System	0.0228	4
Awareness Campaign	0.1122	4
System Reviews	0.4524	4
Useful Procedures	0.5476	4
Management Commitment	0.7831	4
Pre-assessment Audit	0.8341	4
System Manual	0.9998	4

A non-parametric 1-Sample Sign test of the medians is used to test the null hypothesis H_0: median = 4 versus H_1: median < 4. From Table 4.7, we can reject the null hypothesis for any activities with a p-value less than .05. Therefore, we can accept H_0, that the median rating for External Consultants, System Training, and Documentation System were less than the other implementation activities. The median rating of Awareness Campaign, System Reviews, Useful Procedures, Management Commitment, Pre-assessment Audit, and System Manual were essentially the same.

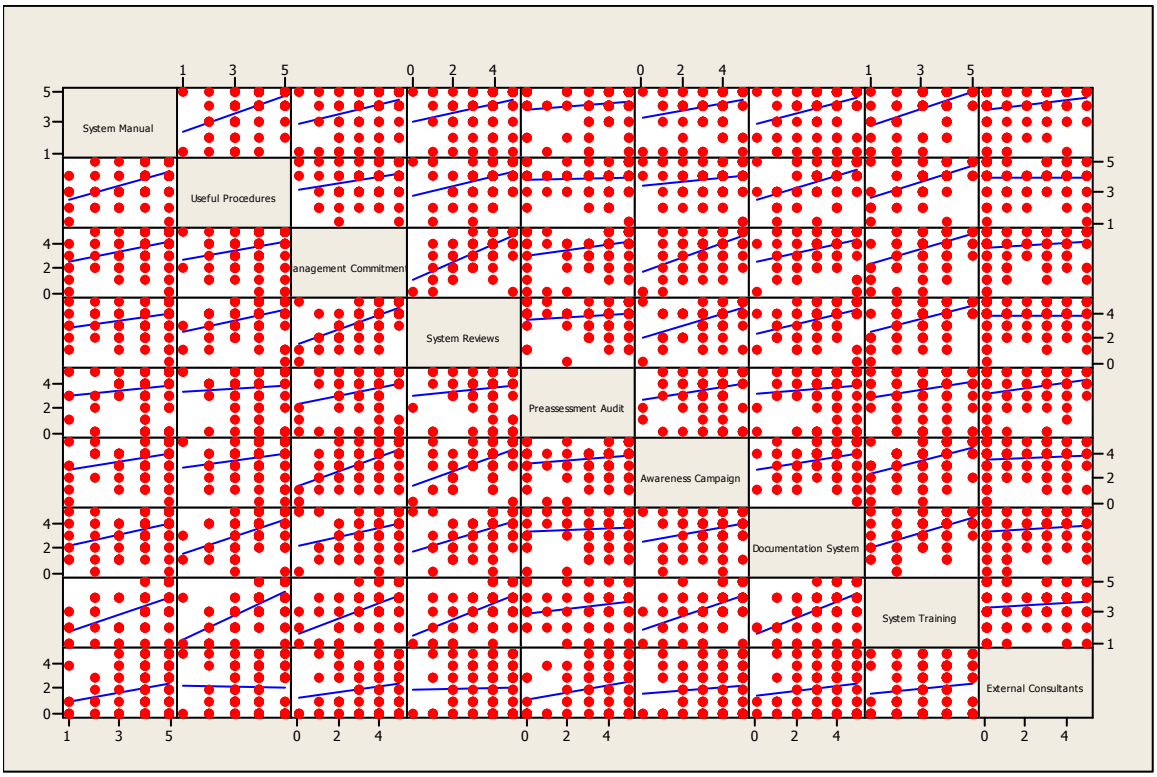

Figure 4.7 Matrix of Implementation Activity Plots with Regression Line Fits

Figure 4.7 is an array of scatter plots of all of the implementation activities graphically showing the relationship between each pair. The plots also include a regression line. In all of the plots involving External Consultants, the regression line is

nearly horizontal, indicating a weak correlation or no relationship. By contrast, the plots involving System Training generally show a regression line with a 45° angle indicating a positive correlation.

Table 4.8 shows the Spearman rank correlations between implementation activity ratings. Again, the use of external consultant rating has little or no relationship to other activities based on the average ratings from the survey respondents. The pre-assessment audit has a fairly weak correlation to management commitment but no significant correlation to other activities. The rating of management system training has a moderate relationship to almost all other activities.

Table 4.8 Correlation Between Implementation Activities

	System Manual	Useful Procedures	Mgt. Commitment	System Reviews	Preassessment audit	Awareness Campaign	Doc. System	Mgt. System Training
Useful Procedures	0.523							
Mgt. Commitment	0.412	0.369						
System Reviews	0.4	0.413	0.658					
Preassessment audit	0.284	0.245	0.363	0.252				
Awareness Campaign	0.374	0.299	0.586	0.599	0.331			
Doc. System	0.424	0.527	0.383	0.494	0.149	0.328		
Mgt. System Training	0.531	0.647	0.535	0.484	0.335	0.496	0.554	
External Consultants	0.222	-0.046	0.126	-0.013	0.143	0.078	0.112	0.134

0 to .25 = No relationship
.25 to .50 = Fair relationship
.51 to .75 = Moderate relationship
.75 to 1 = Good relationship

A further examination of the data was undertaken to compare the responses in relation to the environmental factors: large business versus small business, internally

motivated certifications versus externally motivated certifications, newer certifications versus older certifications, and manufacturing versus non-manufacturing industry.

Table 4. 9 Kruskal-Walis Median Test of Environmental Factors Effect on Implementation Activities

	No. of Employees	Large vs. Small	Year Certified	Recent vs. Old Cert.	Primary Reason for Cert.	Primary Reason for Cert. (Int. vs. Ext.)	Mfg. vs. Non-Mfg.
System Manual	0.488	0.444	0.882	0.404	0.082	0.016	0.227
Useful Procedures	0.623	0.449	0.809	0.963	0.179	0.041	0.045
Mgt. Commitment	0.062	0.344	0.167	0.17	0.141	0.077	0.17
System Reviews	0.791	0.891	0.87	0.383	0.062	0.018	0.009
Pre-assessment Audit	0.391	0.064	0.856	0.783	0.722	0.729	0.02
Awareness Campaign	0.949	0.784	0.882	0.611	0.012	0.009	0.26
Doc. System	0.609	0.653	0.52	0.506	0.105	0.015	0.402
System Training	0.834	0.567	0.313	0.072	0.071	0.004	0.024
External Consultants	0.784	0.5	0.198	0.028	0.304	0.861	0.61

Table 4.9 shows the p-values from a Kruskal-Wallis Test on the significance of each environmental factor for all of the implementation activities. The null hypothesis (H_0) that the medians of each factor level are equal is tested against the alternate hypothesis (Ha) that the median for each factor level is not the same. In the first column of the table, the results for number of employees at the companies indicate there was no significant difference in the factor levels for any of the implementation activities. The survey asked respondents to select from five levels for company size (1 = 1 to 50, 2 = 51 to 100, 3 =

101 to 500, 4 = 501 to 1000, 5 = more than 1000). This means that companies with few employees or a large number of employees implemented their management system with essentially the same set of activities and did not emphasize specific activities differently. The second column of the table is titled "Large vs. Small" and repeats the test of the first column except the five company size levels were collapsed into two levels. The U.S. Bureau of Labor Statistics defines small businesses for most industries as companies having fewer than 500 employees. The second column compares the companies with fewer than 500 employees with those having more than 500 employees, and this data did not yield any significant differences between the two groups.

The third column of the table lists the results based on the year that they first obtained certification. The Year Certified data was categorized into five factor levels: 1 = 2007 to 2004, 2 = 2003 to 1999, 3 = 1998 to 1996, 4 = 1995 or earlier. The data shows that there was no significant difference between the companies that were certified recently and those that went through the certification process many years ago.

The next column titled "Recent vs. Old Cert." collapsed the data into two levels, recent = after 2004 and older certification = before 2004. The companies that were granted certification years ago have gone through additional re-certifications every three years. Some organizations might elect not to renew their certification at this milestone if they perceive limited value from certification. The p-values for only one implementation activity indicate a significant difference in factor levels, Use of External consultants. External consultants were used to a lesser extent by organizations that more recently became certified than those organizations that were certified years ago.

The fifth and sixth columns of the table have data related to the impact of the organization's primary reason for seeking external certification of their quality management system. The data from the survey was categorized into the following eight factor levels: 1= To Reduce Costs, 2 = Quality Benefits, 3 = Management Initiated, 4 = Global Competitiveness, 5 = Preferred Supplier Status, 6= Government Requirements, 7 = European Community Mandate, and 8 = Customer Request. There was not a significant difference in the use of any of the implementation activities based on their motivation for seeking certification except for the awareness campaign. The p-value for use of an awareness campaign indicates that there were differing uses of this implementation activity depending on the primary reason that the organization was certifying its quality management system. To gain more insight into this difference, the data was grouped into two categories of motivation. The first four factor levels were considered internal reasons to seek certification, and the second four factor levels were classified as external motivation. The seventh column, titled "Primary Reason for Cert. Internal vs. External," shows the p-values using only the two factor levels. Six of the nine activities (System Manual, Useful Procedures, System Reviews, Awareness Campaign, Doc. System, and System Training) were rated differently depending on whether the organization was internally or externally motivated to seek certification.

The last column of the table analyzes the responses in light of the organizations' industry classification. The survey respondents selected their industry classification using a drop-down list of 34 NAICS codes, and then their responses were grouped into the two factor levels, manufacturing and non-manufacturing. The p-values show that four activities were used differently between the two groups (Useful Procedures, System

Reviews, Pre-assessment audit, and System Training). They had lower use in manufacturing organizations.

One of the implementation activities, Management Commitment, was not rated differently considering any of the environmental factors. The survey instrument described management commitment as:

> Management commitment for the ISO 9001 certification was evident in that executives, supervisors, and employees demonstrated support through their words and behaviors.

This might suggest a universal understanding of the concept and its importance that transcends industries, company size, and time. Comments concerning management commitment will be discussed in the next section.

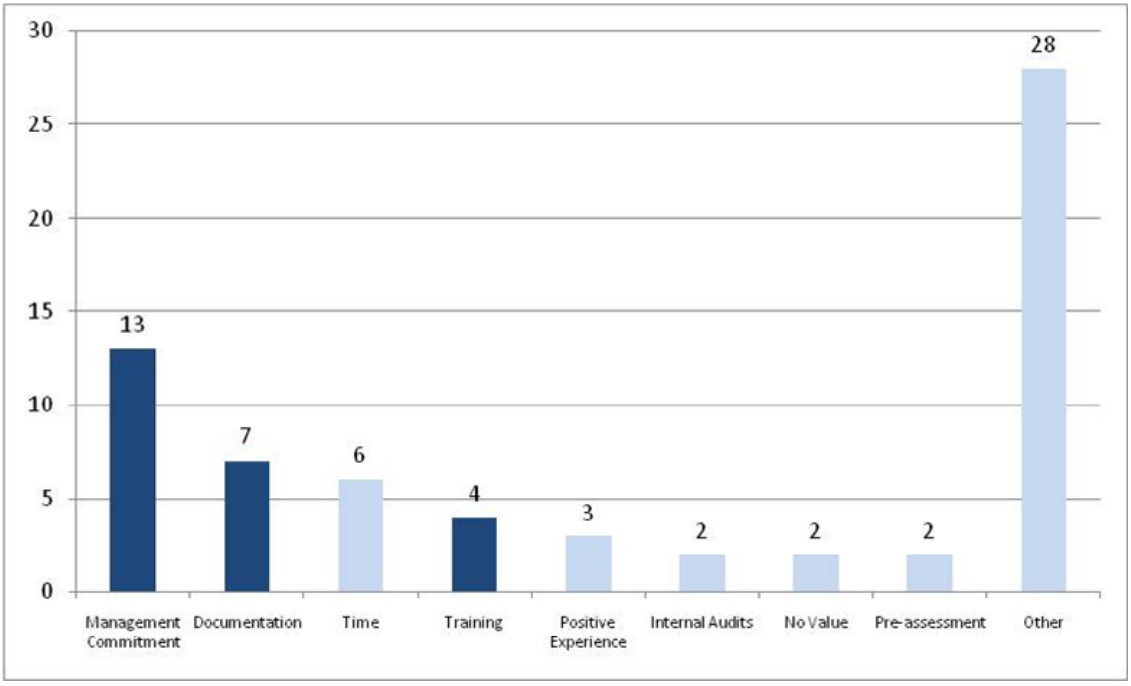

Figure 4.8 Distribution of Comments About Seeking ISO 9000 Certification

Implementation Comments

The survey also included a free text area that allowed respondents to provide comments about their experience becoming certified. Sixty-seven comments were received. Figure 4.8 shows that more than one-third of the comments fell into the three categories: certification process, documentation, and training. These three areas have a moderate to strong relationship with each other as seen in the correlation values in Table 4.8.

Some representative comments are listed below:

Management Commitment

- "Lack of top mgt support made the journey that much tougher."
- "We had total buy-in from the top down."

Training

- "Though quality systems existed prior to the certification, the company benefitted a great extent during the training programs. Workers' participation and involvement were brought out into the open."
- "Internal auditor training (with internal trainers was difficult in the beginning), it took a few years before we were able to interpret and transform the requirements into something useful."

Documentation

- "Required huge efforts for paperwork disconnected from quality of the product"
- "Going through the process has allowed us to improve our current document control processes and implement a more structured approach to management."

It is important to note that the comments reflected both positive and negative experiences in these three areas.

Implementation Activity Discussion

Comments from implementers, along with their use of the implementation activities indicated in Table 4.6, show that the implementation process requires focus on creating a workable, user-friendly documentation system and training employees on how to create and maintain system documentation. Organizations should focus on what they will gain from implementing ISO 9000 and infusing this idea into their training process to create the right documentation. The data suggest different emphasis in their process to gain certification based on their primary motivation for seeking certification and their industry.

Table 4.10: Average Rating of ISO 9000 Elements Performance

	Control of Documents	Customer Focus	Management Reviews	Process Focus	Closed Loop Corrective Action
All	**4.01**	3.96	3.82	3.79	3.45
Median	4	4	4	4	3
Mode	4	4	4	4	3
Std	0.74	0.70	0.81	0.79	**0.90**

Quality Management System Performance Outcomes

Table 4.10 shows the average rating of the ISO 9000 system elements on the survey. The elements are sorted from highest to lowest average rating; control of documents was rated highest and corrective action system performance rated the worst. A non-parametric 1-Sample Sign test of the median is used to test the significance of the difference in medians with the null hypothesis H_0: median = 4 median versus H_1: median < 4. We can reject the null hypothesis for any activities with a p-value less than .05. Therefore, we can say that Management Reviews, Process Focus, and Closed Loop

Corrective Action were given lower performance ratings than the Customer Focus and Document Control as shown in Table 4.11.

Table 4.11 System Performance – Sign Test on Median Differences

ISO 9000 Element	*P*	*Median*
Closed Loop Corrective	0.0000	3
Process Focus	0.0140	4
Management Reviews	0.0270	4
Customer Focus	0.5000	4
Control of Documents	0.8342	4

The reliability of the data was evaluated using an internal consistency Cronbach's alpha coefficient. The coefficient of .778 indicates that the errors due to administration of the survey are small enough that we can confidently use the data from this assessment. Table 4.12 shows the correlation between the management system outcomes. Control of Documents and Customer Focus received the two highest ratings of the system elements from the respondents; however, their performance ratings have a low correlation to each other. The highest correlation is between Process Focus and Closed Loop Corrective Action, the correlation value of 0.605 indicates that a moderate to good relationship exists between them. These elements had the lowest performance ratings. This might be an area where synergistic improvements can be readily made.

Table 4.12 Correlation of System Performance

	Control of Documents	Customer Focus	Management Reviews	Process Focus
Customer Focus	0.250			
Management Reviews	0.288	0.376		
Process Focus	0.356	0.485	0.501	
Closed Loop Corrective	0.356	0.425	0.538	0.605

The outcome variables were examined with respect to the environmental factors of company size, reason for certification, duration of certification, and industry classification. Table 4.13 shows the results of the Kruskal-Wallis test on the median responses to determine the significance of each environmental factor. The null hypothesis (H_0) that the medians of each factor level are equal is tested against the alternate hypothesis (Ha) that the median for each factor level is not the same.

Table 4.13 Kruska Walis Median Test of Environmental Factor's Effect on ISO 9000 Element Performance

	No. of Employees	Year Certified	Primary Reason for Certification	Primary Reason for Cert. (Int. vs. Ext.)	Mfg. Vs. Non-Mfg.
Control of Documents	0.573	0.731	0.854	0.318	0.254
Customer Focus	0.636	0.75	0.017	0.03	0.013
Management Reviews	0.426	0.354	0.056	0.008	0.026
Process Focus	0.285	0.708	0.037	0.009	0.019
Closed Loop Corrective Action	0.844	0.339	0.266	0.021	0.013

The p-values in the first column of Table 4.13 do not support rejecting the hypothesis that for differing levels of "Number of Employees," the medians are the same. Therefore, we conclude that this environmental variable did not have an effect on the data. It was expected that company size would affect the system element performance and that smaller businesses might have had less success than larger businesses. This suggests that once the organizations are certified, the quality management systems perform that same.

The p-values in the second column of the table do not support rejecting the hypothesis that for differing levels of "Years Certified," the medians are not the same. This implies that organizations that have passed multiple recertification audits perform the same as those organizations that have been more recently certified.

The third column of the table shows data related to the impact of the organization's primary reason for seeking external certification of its quality management system. The p-values show that only the performance of "Customer Focus" and "Process Focus" were rated differently based on the organization's reason for becoming certified. The fourth column also involves the data related to the reason for certification. The eight levels were collapsed into just two: Internal Reasons and External Reasons. European Community Mandate, Preferred Supplier, Government Requirements, and Customer Request were considered external reasons while Reduce Cost, Global Competiveness, Quality Benefits, and Management Initiated were considered internal reasons. The analysis for the collapsed data shows that all of the system elements except Control of Documents were rated differently based on the organization's motivation.

The last column of the table analyzes the responses in light of the organization's industry classification of manufacturing or non-manufacturing. This environmental variable was significant for all of the system elements except Control of Documents. The rating of performance of Control of Documents did not change significantly depending on the company size, year of certification, motivation for certification, or the industry.

Table 4.14 shows the results of the Kruskal-Wallis test on the median responses to determine if there is a statistically significant difference between the responses from quality professionals (quality engineers, quality supervisor, director of quality, etc., or

people working in a quality department) and other respondents. The table shows that the median ratings are the same and at the 90% confidence level, p-values are not significant, indicating the data is not biased by responses from quality professionals rating the system performance higher than other respondents.

Table 4.14 Kruska Wallis Test (p-values) on Quality Department vs. Other Respondents Performance Measures

	Control of Documents **Median Rating**	Customer Focus **Median Rating**	Management Reviews **Median Rating**	Process Focus **Median Rating**	Corrective Action **Median Rating**
Other Dept.	4.000	4.000	4.000	4.000	3.500
Quality Dept.	4.000	4.000	4.000	4.000	3.000
P-Value	**0.783**	**0.369**	**0.334**	**0.952**	**0.487**

Quality Management System Performance Comments

In addition to rating the performance of the quality management system using the Likert scale, the survey respondents were given the opportunity to provide comments on the performance of their quality management system. The distribution of comments is shown in Figure 4.9. Comments about two of the quality system elements, documentation and customer focus, accounted for 20% of all of the comments. These areas were also rated as the two highest performing areas by the survey respondents. Example comments below support the importance of these two elements

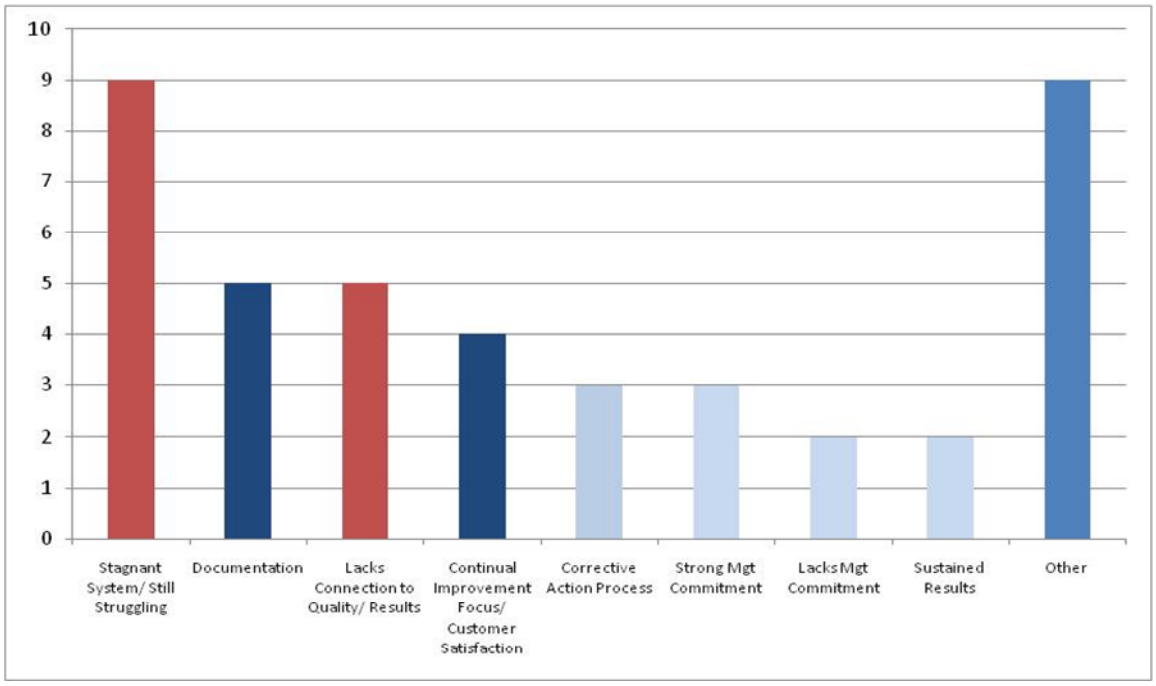

Figure 4.9 Distribution of Comments Concerning the Quality Management System

In addition, a large portion of comments (33%) reflected negatively on the implementation of the system. They fell into two groups, Still Struggling and Lack of Connection to Results.

Connection Between Implementation Elements and System Performance Outcomes

This section will attempt to make a connection between the certification activities and post-certification quality management system outcomes. The Spearman's Rho correlations between the implementation factors and the system outcomes are shown in Table 4.15.

A moderate positive relationship exists between emphasis on the Documentation System during implementation and the rating of Process Focus performance. Also, a moderate positive relationship exists between emphasis on the Documentation System

implementation activity and performance of the Documentation Control function. The correlation between implementation emphasis and performance of documentation control is validation that this particular area should yield positive outcomes for companies when given the appropriate attention during implementation.

Table 4.15 Process and Outcome Correlations

	System Manual	Useful Procedures	Mgt. Commitment	System Reviews	Pre audit	Awareness Campaign	Doc. System	Mgt. System Training	External Consultants
Control of Doc.	0.308	0.460	0.238	0.329	0.105	0.158	0.527	0.292	-0.180
Customer Focus	0.231	0.373	0.306	0.268	0.103	0.255	0.263	0.321	-0.110
Mgmt. Review	0.407	0.479	0.494	0.451	0.133	0.392	0.336	0.466	-0.058
Process Focus	0.401	0.463	0.489	0.444	0.124	0.260	0.543	0.482	-0.035
Closed Loop	0.390	0.401	0.283	0.310	0.192	0.266	0.357	0.403	-0.001

From the correlation values in Table 4.15, the most likely candidates for a regression model relating the activities with outcomes would be between Documentation System implementation activity and the performance of Process Focus. A visual examination of the scatter plot shown in figure 4.10 does not indicate a strong relationship between them.

The survey response variables were collected as categorical responses with a natural ordering so the most appropriate techniques for this type of data is an Ordinal Logistic Regression model. Using the Ordinal Logistic Regression function in MINITAB® statistical software, a regression equation was created. The output is displayed in Figure 4.11.

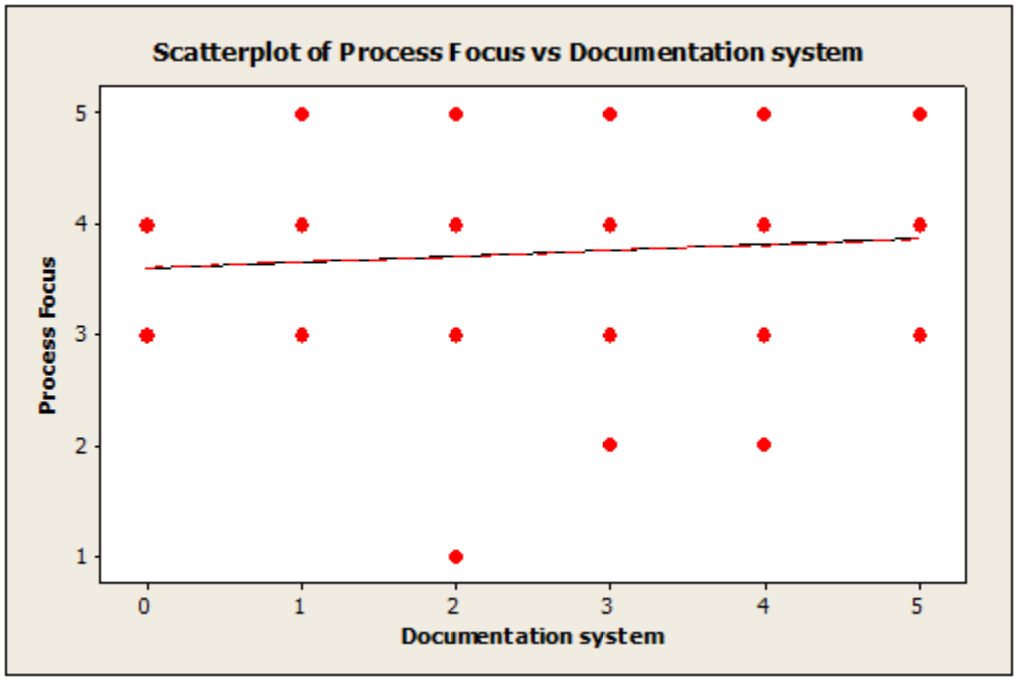

Figure 4.10 Process Focus vs. Documentation System Scatter Plot

Ordinal Logistic Regression: Process Focus versus Documentation System

```
Link Function: Logit

Response Information

Variable       Value  Count
Process Focus  1          1
               2          7
               3         27
               4         68
               5         18
               Total    121

Logistic Regression Table

                                                          Odds      95% CI
Predictor                 Coef    SE Coef       Z      P  Ratio   Lower   Upper
Const(1)              -4.41482    1.10943   -3.98  0.000
Const(2)              -2.27449   0.599804   -3.79  0.000
Const(3)             -0.522112   0.523053   -1.00  0.318
Const(4)               2.13183   0.564721    3.78  0.000
Documentation System -0.107524   0.138873   -0.77  0.439   0.90    0.68    1.18

Log-Likelihood = -138.411
Test that all slopes are zero: G = 0.634, DF = 1, P-Value = 0.426


Goodness-of-Fit Tests

Method     Chi-Square  DF      P
Pearson      16.2217   19  0.642
Deviance     15.6517   19  0.680
```

Figure 4.11 MINITAB Output from OLR for Process Focus

Examining the p-value for the estimated coefficient for Documentation System, 0.439, there is insufficient evidence to conclude that it has an effect upon Process Focus. The p-value for the test that all slopes are different from zero indicates that there is insufficient evidence to conclude they are not zero. The Goodness-of-Fit Tests suggest that the model does fit the data; however, since the coefficient for Documentation System is not significant, the model is useless.

From the correlation values in Table 4.7, the next most likely candidates for a regression model relating the activities with outcomes would be between the Documentation System implementation activity and the performance of Documentation Control. The names of this pair also suggest that there might be a significant relationship. However, a visual examination of their scatter plot does not reveal a strong relationship between them.

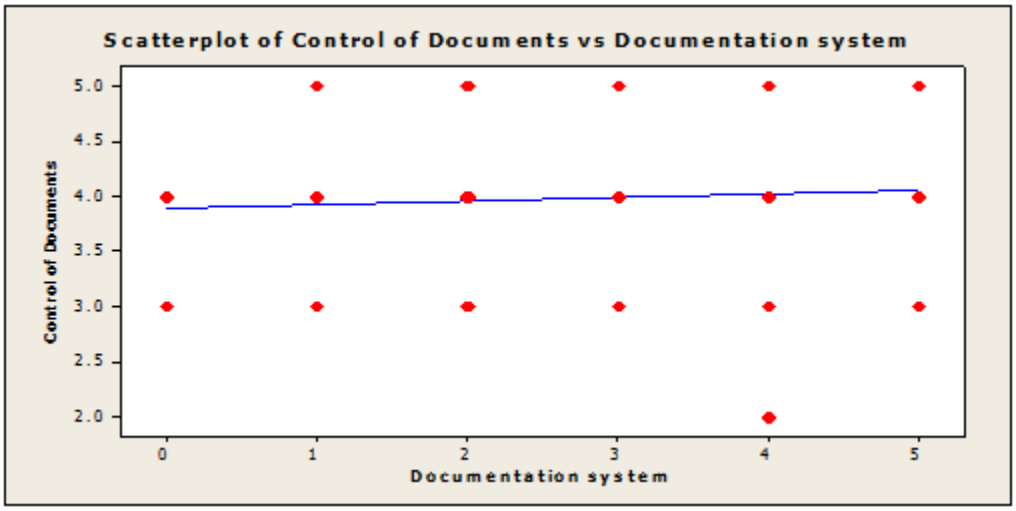

Figure 4.12 Scatter Plot of Control of Documents vs. Documentation System

Using the Ordinal Logistic Regression function in MINITAB® statistical software, a regression equation was created. The MINITAB information is shown in Figure 4.13. The p-value for the estimated coefficient for Documentation System is 0.335; this provides insufficient evidence to conclude that it has a significant effect upon the performance Control of Documents in the regression model. The p-value for the test

Ordinal Logistic Regression: Control of Documents versus Documentation System

```
Link Function: Logit

Response Information

Variable              Value  Count
Control of Documents  2          5
                      3         18
                      4         69
                      5         29
                      Total    121

Logistic Regression Table

                                                          Odds     95% CI
Predictor                 Coef   SE Coef      Z      P  Ratio  Lower  Upper
Const(1)              -2.68087  0.659795  -4.06  0.000
Const(2)              -0.986290  0.535245  -1.84  0.065
Const(3)               1.63626  0.552219   2.96  0.003
Documentation System  -0.135635  0.140572  -0.96  0.335   0.87   0.66   1.15

Log-Likelihood = -129.962
Test that all slopes are zero: G = 0.900, DF = 1, P-Value = 0.343

Goodness-of-Fit Tests

Method    Chi-Square  DF      P
Pearson      31.1377  14  0.005
Deviance     31.6434  14  0.005
```

Figure 4.13 MINITAB Regression Output Control of Docs vs. Documentation System

that all slopes are different from zero indicates that there is insufficient evidence to conclude they are not zero. The Goodness-of-Fit Tests suggest that the model does fit the data; however, since the coefficient for Documentation System is not significant, the model is useless.

Other subset combinations of process and outcome variables were tested, and none of them yielded significant results. There was no significant regression model connecting a specific set of implementation activities and any quality management system performance outcomes. These regression models attempted to establish a linear relation, which does not seem to apply.

Analysis of Survey Performance Measure Responses

According to Quality Management Systems Fundamentals and Vocabulary ISO 9000:2005, effectiveness is defined as "the extent to which planned activities are achieved." This section provides an analysis of business performance measures that are most appropriate to understand the impact or effectiveness of the quality management system. The survey asked participants to rate the usefulness of seventeen performance measures that were commonly used to assess organizational performance. Researchers have previously used the measures listed in Table 2.2 when investigating the efficacy of ISO 9000 certification. The results of the ranking from the survey are shown in Figure 4.14. The four measures that were rated most useful were:

- Operating Costs
- Net Profit Margin
- Sales Increase
- Defect Rates

These four measures are considered to be the most useful to manage the organization and could help determine if implementing the quality management system was effective and impacted the organization's performance.

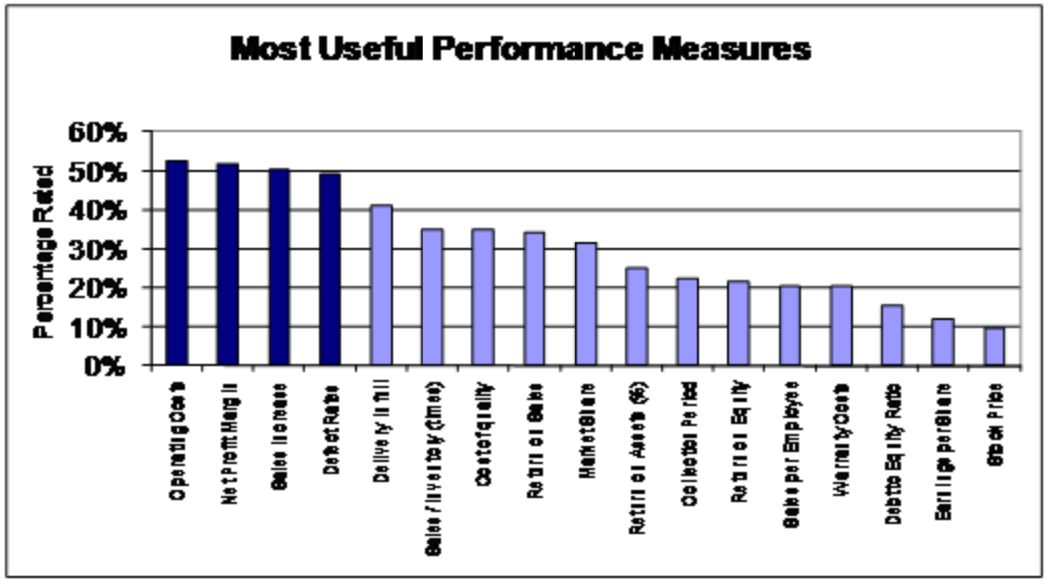

Figure 4. 14 Usefulness Ranking of Performance Measures

A non-parametric sign test on the median rating confirms that these four were rated significantly higher than the other measures. The National Association of Investment Clubs' Better Investing Guide uses four tests for picking a quality company (http://www.betterinvesting.org). Its method includes reviewing Sales Growth, Earning Per Share, Pre-Tax Profit, and Return On Equity. Two of these four tests were represented in survey respondents' top picks.

An analysis of three environmental factors; company size, industry and year certified, was performed to better understand which measure would be most useful given a specific environment. The survey instrument collected company size data in five levels; however, testing all of the performance measures against the five levels revealed no difference in rating until the data was collapsed down to two levels. The first column of table 4.16 represents the results of comparing the two levels, companies with less than 500 employees against ratings for companies with more than 500 employees. The

performance measures that were ranked most useful by the least number of survey respondents were:

- Warranty Costs
- Debt to Equity Ratio
- Earnings per Share
- Stock Price

In addition to being ranked at the bottom, these four measures show a significant difference in rating based on company size. These financial measures were always rated less useful by smaller companies than by larger companies. Also, Market Share and Return On Assets were rated differently based on company size. Both of these were more useful to larger companies than smaller ones. However, neither the industry nor when the company was certified made a difference in how companies rated these measures.

In the column titled "Recent vs. Older Certification," two measures (Net Profit Margin and Inventory Turns) were rated significantly different based on years of certification. Both were more useful to companies that have been certified for more than nine years. This might indicate that companies with more mature quality management systems are looking beyond the efficiencies initially gained by formalizing their management system and are looking to improve their overall profit margin and supply chain effectiveness. Early proponents of ISO 9000 certification suggested that it would improve the global supply chain by reducing the need for supplier audits. None of the other measures were rated differently based on the amount of time the company had been certified.

Table 4.16 Kruskal Wallis Test (p-values) on Environmental Factors Affecting Organizational Performance Measures

Performance Measure	Large vs. Small	Recent vs. Old Cert.	Mfg. vs. Non-Mfg.
Operating Costs	0.130	0.349	0.873
Net Profit Margin	0.408	0.030	0.259
Sales Increase	0.811	0.525	0.261
Defect Rates	0.920	0.478	0.035
Delivery in full	0.442	0.163	0.000
Sales / Inventory (times)	0.42	0.008	0.029
Cost of quality	0.763	0.677	0.846
Return on Sales	0.363	0.051	0.054
Market Share	0.002	0.052	0.482
Return on Assets (%)	0.048	0.800	0.740
Collection Period	0.854	0.915	0.424
Return on Equity	0.057	0.724	0.894
Sales per Employee	0.079	0.201	0.666
Warranty Costs	0.046	0.115	0.211
Debt to Equity Ratio	0.012	0.669	0.871
Earnings per Share	0.000	0.646	0.215
Stock Price	0.000	0.582	0.673

The last column of the table analyzes the responses in light of the organization's industry classification of either manufacturing or non-manufacturing. The original ISO 9000 standard was primarily targeted at manufacturing companies and has since been generalized to accommodate any type of organization. This environmental variable was significant for only Defect Rates, Delivery in Full, Sales/Inventory (times). These three measures were rated more useful for manufacturing companies than non-manufacturing companies.

Seven of the performance measures were not rated significantly different with respect to any of the environmental variables:

- Operating Costs

- Sales Increase
- Cost of Quality
- Return on Sales
- Collection Period
- Return on Equity
- Sales per Employee

This set of measures was found be equally useful across a broad spectrum of organization sizes and industries.

Connection Between Financial Data and Quality System Implementation Elements

Mergent Online provides detailed financial reports concerning companies throughout the world and is an independent source of data that is processed through a rigorous multi-stage validation process (Mergent Online, 2009). The survey respondents' data was matched with their publically available financial measures from Mergent Online. Twenty-two companies had data in the Mergent system. Five financial measures were used:

- ROE (Three-Year Average)
- ROA (Three-Year Average)
- Profit Margin % (Three-Year Average)
- Operating Margin (Three-Year Average)
- Annual Revenue Growth (Five Year Compounded)

A Spearman's Rho correlation matrix of the financial data is displayed in table 4.17 and allows an analysis of any relationships between the measures. The strongest relationships

in this sample appear to be Profit Margin & ROA, Operating Margin & ROA and Operating Margin &Profit Margin.

The distribution of the financial data was assessed with histogram plots and a normal curve overlay shown in figure 4.15 to determine its suitability for a regression model. The Return On Assets data is the only one that can be said to be normally distributed based on its Anderson-Darling score (0.218) and p-value 0.815.

Table 4.17 Correlation Matrix of the Financial Data

	ROA	ROE	Op Margin	Profit Margin	Revenue per Employee
ROE	0.412				
Op Margin	0.653	0.286			
Profit Margin	0.975	0.477	0.678		
Revenue per Employee	0.13	0.018	0.107	0.128	
Annual Growth	0.001	-0.337	0.059	-0.037	0.417

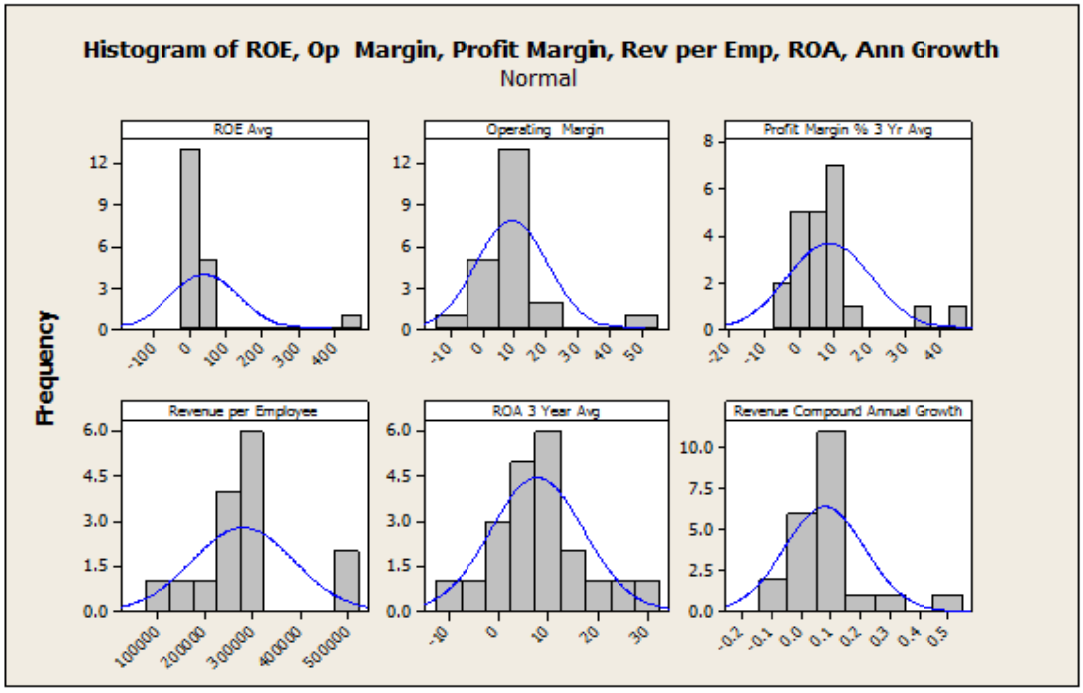

Figure 4.15 Financial Data Comparisons with Normal Distribution

Scatter plots of the ROA data against each of the implementation elements indicates any potential relationships. The most promising are relationships with System Reviews, Document System and External Consultants. Regression equations were developed to connect the implementation activities with the financial measure. The output from the MINITAB Regression was reviewed to determine if any of the equations were useful.

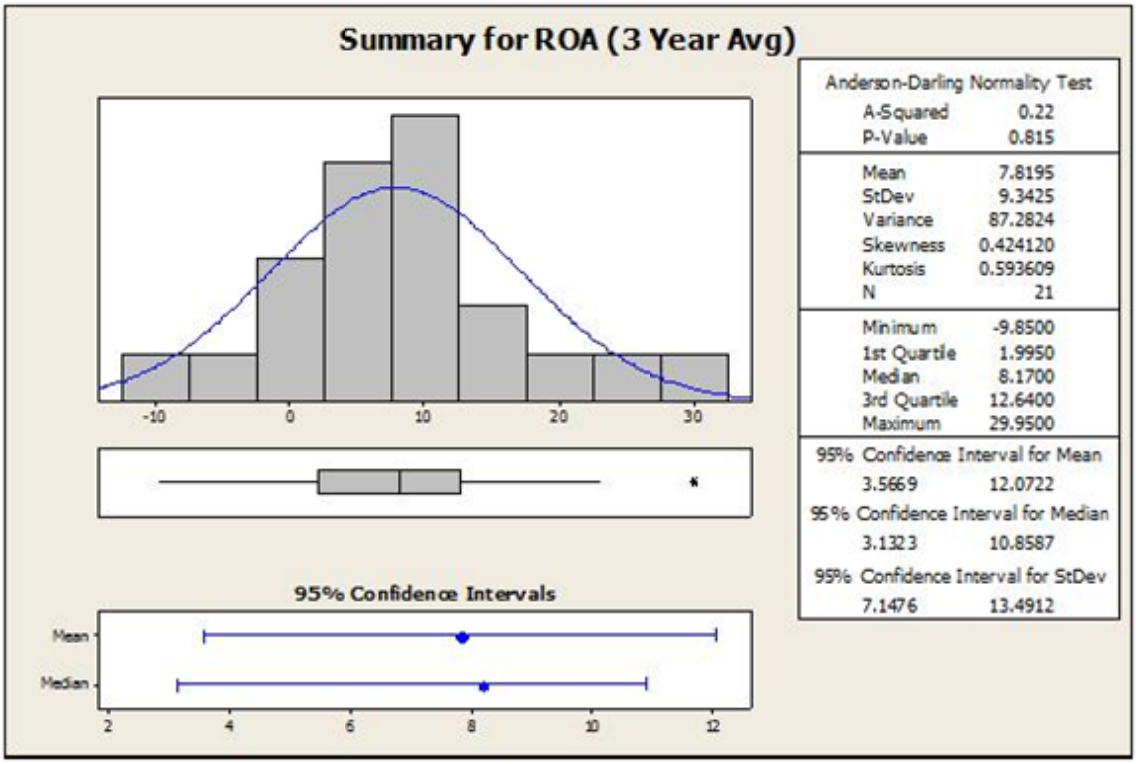

Figure 4.16 Summary of Return On Assets Data

Regression Model for Return On Assets

The Return On Asset (ROA) is seen as an indicator of how effective the company's assets are being used to produce profit. Mergent calculates the ROA from the Annualized Net Income expressed as a percentage of Average Total Assets. ROA data from 2006 through 2008 was downloaded from the Mergent system and analyzed in MINITAB. A graphical summary of the ROA data is show in Figure 4.16. The Anderson-

Darling normality value shows the ROA data set to be normally distributed and centered around 7.8

A matrix scatter plot of the ROA data with each of the implementation elements shown in figure 4.17 indicates that ROA-System Reviews, ROA-Documentation System and ROA-External Consultants might have significant relationships.

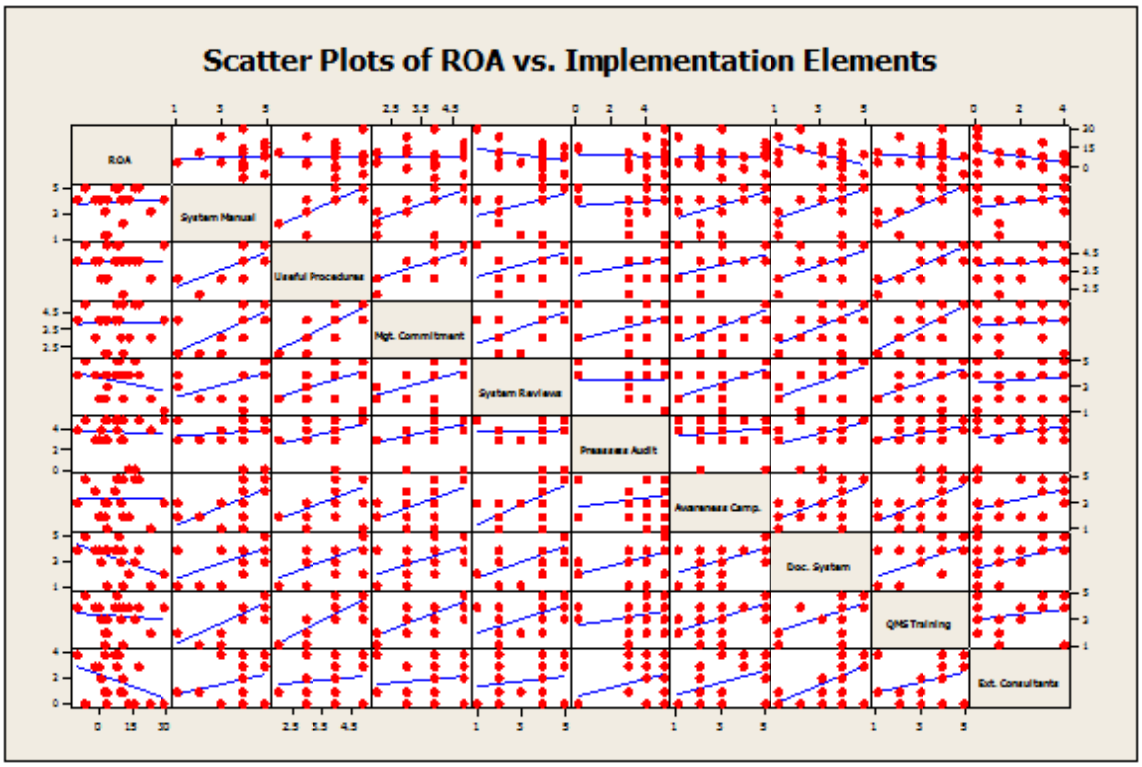

Figure 4. 17 Scatter Plots of ROA vs. Implementation Elements

In Figure 4.18, the MINITAB regression output for the Return On Assets and the implementation element External Consultant is shown. The p-value of the Analysis of Variance table (0.095) indicates that the relationship between ROA and External Consultant use is not significant at the α-level of 0.05. Also, the p-value for the estimated coefficient of External Consultants (0.095) is not significant. The R^2 value shows that

External Consultants explains only 14% of the variance in ROA, indicating that the model does not fit the data well.

Regression Analysis: ROA versus External Consultants

The regression equation is
ROA = 12.0 - 2.17 External consultants

Predictor	Coef	SE Coef	T	P
Constant	11.953	3.049	3.92	0.001
External consultants	-2.170	1.235	-1.76	0.095

S = 8.89016 R-Sq = 14.0% R-Sq(adj) = 9.4%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	243.98	243.98	3.09	0.095
Residual Error	19	1501.66	79.03		
Total	20	1745.65			

Figure 4.18 Return On Assets vs. External Consultants Regression Model

In Figure 4.19,the MINITAB regression output for Return On Assets and the implementation element Documentation System is displayed. The p-value of the Analysis of Variance table (0.021) indicates that the relationship between ROA and Documentation System use is significant at the α-level of 0.05. This is also confirmed by the p-value for the estimated coefficient of the Documentation System (0.021) in the equation. The R^2 value shows that 25.1% of the variation in ROA is explained by the Documentation System implementation activities. Emphasis on this activity during certification does seem to have an effect on organization's Return On Assets.

Regression output for Return On Assets and the implementation element System Reviews is displayed in figure 4.20 . The p-value of the Analysis of Variance table (0.210) indicates that the relationship between ROA and System Review use is not

significant at the α-level of 0.05. This is also confirmed by the p-value for the estimated coefficient of the System Reviews (0.0210) in the equation. The R^2 value shows that 8.2% of the variation in ROA is explained by the System Review implementation activities which is not useful for prediction.

Regression Analysis: ROA versus Documentation System

The regression equation is
ROA 3 Year Avg = 20.4 - 3.78 Documentation system

Predictor	Coef	SE Coef	T	P
Constant	20.409	5.313	3.84	0.001
Documentation system	-3.777	1.498	-2.52	0.021

S = 8.29767 R-Sq = 25.1% R-Sq(adj) = 21.1%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	437.47	437.47	6.35	0.021
Residual Error	19	1308.18	68.85		
Lack of Fit	3	220.43	73.48	1.08	0.385
Pure Error	16	1087.74	67.98		
Total	20	1745.65			

Figure 4. 19 Return On Assets vs. Documentation System

Regression Analysis: ROA versus System Reviews

The regression equation is
ROA 3 Year Avg = 15.6 - 2.21 System reviews

Predictor	Coef	SE Coef	T	P
Constant	15.595	6.313	2.47	0.023
System reviews	-2.207	1.699	-1.30	0.210

S = 9.18607 R-Sq = 8.2% R-Sq(adj) = 3.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	142.35	142.35	1.69	0.210
Residual Error	19	1603.29	84.38		
Lack of Fit	3	384.43	128.14	1.68	0.211
Pure Error	16	1218.86	76.18		
Total	20	1745.65			

Figure 4.20 Return On Assets versus System Reviews

Regression Analysis: ROA versus Customer Focus

The regression equation is
ROA 3 Year Avg = - 12.7 + 4.85 Customer Focus

Predictor	Coef	SE Coef	T	P
Constant	-12.72	13.89	-0.92	0.371
Customer Focus	4.847	3.245	1.49	0.152

S = 9.06752 R-Sq = 10.5% R-Sq(adj) = 5.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	183.47	183.47	2.23	0.152
Residual Error	19	1562.18	82.22		
Total	20	1745.65			

Figure 4. 21 Return On Assets vs. Customer Focus Regression Model

A regression equation was created to connect the quality management system component Customer Focus with the financial performance of the company in terms of ROA. The MINTAB output is displayed in Figure 4.21. The p-value of the Analysis of Variance table (0.152) indicates that the relationship between ROA and Customer Focus is not significant at the α-level of 0.05. This is also shown by the p-value for the estimated coefficient of Customer Focus (0.152) is not significant. The R^2 value shows that External Consultants explains only 11% of the variance in ROA, indicating that the model does not fit the data well.

The scatter plot in Figure 4.22 of the ROA with the Customer Focus ratings shows a slight positive upward trend that both variables increase together. Calculating the Spearman correlation between the ROA and the Customer Focus produces a correlation value of 0.366 with a p-value of 0.103. This p-value indicates that the correlation is not significant.

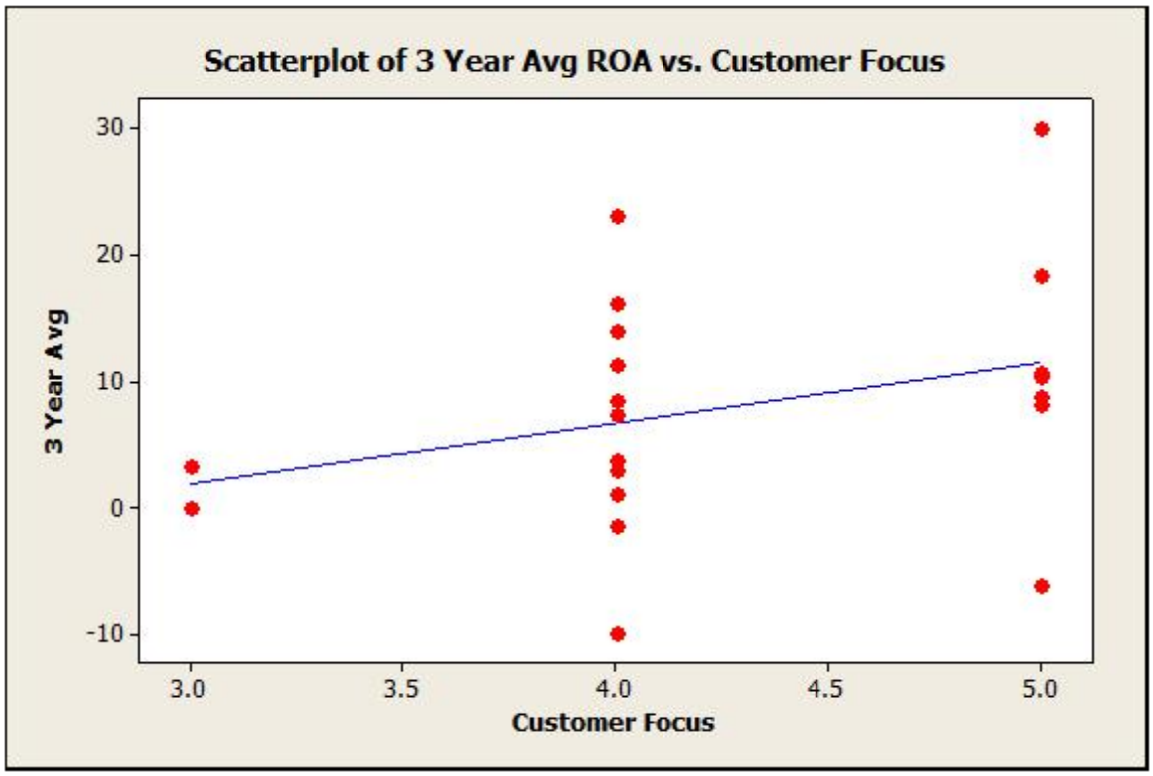

Figure 4.22. Scatter Plot of ROA vs. Customer Focus Ratings.

.

CHAPTER 5: CONCLUSIONS

The purpose of this research was to study the connection between the implementation activities (process) and the management system performance (outcomes). This chapter will offer conclusions drawn from answering the research questions proposed in Chapter 3 and how these conclusions will impact companies seeking to certify their quality management systems.

Implementation Activities

The first conclusions relate to the implementation activities. The three least emphasized implementation activities were Training, Documentation System and External Consultants. These activities had the lowest rating and usage. However, Training had significant correlations with the other values. This suggests that emphasis on training employees during the implementation process necessitates emphasis on the other components. Better training of employees to be proficient in how the components of the system are expected to function should increase the focus on all the components. Training and awareness for a new system implementation should be done with a variety of methods such as classroom, internet technology, or one-on-one. It should also be adaptive, collaborative and self-paced (Clark, 2009).

A second result for the implementation activities analysis is that Use of External Consultants had the least usage and the lowest correlation with any other implementation activities. Also, the Use of an External Consultant did not have a correlation to good performance in any of the system outcome elements. This suggests that organizations'

reliance on an external expert would not have a significant impact on their certification process.

Finally, the emphasis on Management Commitment and emphasis on System Reviews had the highest correlation. The two activities also received high ratings from the respondents. Management Commitment was robust across of the environment factors, so this can be seen as an area of significance to organizations.

Environmental Factors

The environmental factors that were most significant to the implementation activities were the Reason for Seeking Certification and the organization's Industry Classification. Reason for seeking certification was significant for six of the nine implementation activities:

- System Manual
- Useful Procedures
- System Reviews
- Awareness Campaign
- Documentation System
- Management System Training

The internally motivated organizations placed greater emphasis on these six activities than the externally motivated organizations did. The largest difference in rating between internally motivated organizations and externally motivated organizations was in the areas of training and procedures. However, there was no significant difference in emphasis reported for Management Commitment, Pre-Assessment Audit, and Use of External Consultants based on the organization's motivation for seeking certification.

Four implementation activities were used differently based on their industry classification:

- Useful Procedures
- System Reviews
- Pre-Assessment Audit
- Management System Training

All of these activities were rated higher by non-manufacturing organizations than manufacturing organizations. The other activities were not rated differently based on their industry classification.

Quality Management System Performance

Analysis of the system elements reveals that the highest rated system component was Control of Documents. It did not have any strong correlation relationship with any of the other system elements. The strongest correlation relationship between any system elements was between Corrective Action and Process Focus. These two elements received the lowest ratings of the five system elements; however, when respondents rated good performance for Process Focus, they tended to give Corrective Action high marks as well. This suggests that improvements targeted toward Process Focus will also impact the correction system performance.

Environmental Factors

Two of the four environmental factors, Reason for Seeking Certification and Industry Classification, affected the rating of all of the system performance elements except Control of Documents'. The rating Control of Documents did not change significantly depending on the company size, year of certification, motivation for

certification, or the industry. This suggests that Control of Documents is perceived the same across different sized companies and different industries. The other system elements were rated differently depending upon the environmental factors of motivation and industry.

Considering the motivation for certification, internally motivated organizations rated the performance of Customer Focus, Management Reviews, Process Focus, and Closed Loop Corrective Action higher than organizations that were seeking certification for external reasons. The organizations classified as non-manufacturing rated higher the performance of Customer Focus, Management Reviews, Process Focus, and Closed Loop Corrective Action higher than manufacturing organizations.

Implementation Process and Financial Measure Connection

Regression equations based on the five financial measures resulted in one significant equation. A summary of the analysis is shown in Table 5.1.

Table 5.18 Summary of Financial Measure Regression Analysis

Measure	Significant Equation	Significant Variables
Operating Margin	No	N/A
Profit Margin %	No	N/A
ROA	Yes	Documentation System
ROE	No	N/A
Compounded Annual Revenue Growth	No	N/A

The survey respondents ranked Operating Costs as the most useful performance measure, however no regression equation relating the Operating Margin financial data to the

implementation elements was determined to be significant. The Profit Margin was ranked high by survey respondents as useful however the regression equation relating the financial data was not significant. The ROA measure equation was significant, but it was not ranked as useful by the survey respondents. It has been used by other researchers in past studies. The documentation system has been one of the elements of ISO 9000 that causes many complaints from implementers and results in audit findings (McLachlan, 1996). The regression output shows that the overall model fits the data; the slope of the equation is negative indicating companies that place a greater emphasis on creating a user friendly documentation system have lower ROA when certifying their quality management system. Larger, asset intensive companies might put greater emphasis on creating the documentation system during the management system certification process in order to become certified. This suggests larger companies that are very asset-intensive and require expensive equipment to generate a profit have a greater need for information and process documentation to effectively use those assets. Also, Return On Assets was rated differently as a key performance measure based on company size; it was rated less useful by smaller companies than by larger companies.

Implementation Process and Management System Outcome Connection

Examining the process and outcome connections, a significant correlation was found between documentation system implementation and control of documents. The correlation values indicated a moderate relationship. The fact that there was only a moderate relationship between the documentation implementation activity and the performance of the documentation system after certification suggests that other factors affect the relationship that need to be incorporated in a relationship model.

A higher correlation was found between documentation system implementation and process focus. The documentation system implementation statement in the survey read "A user friendly, accessible, and efficient documentation system was established." This statement encompasses elements of a well-defined and managed process that would involve focus on the process and, if done properly, could translate to an overall competency in process management excellence. The popularity of tools such as Six Sigma and supply chain management are oriented toward process management. Further research will be directed toward the state of the art of Process Focus. Although there was a correlation, no linear relationships were established with the regression modeling techniques. A predictive model will likely involve a more complex set of variables related in a non-linear relationship.

Performance Measures

Two of the top-rated measures, Operating Costs and Sales Increase, were robust across all of the environmental factors (company size, industry, length of certification). If the quality management system is looked at as a tool for management to effectively run the organization, the trend in costs and sales should be useful. The research shows that the purely financial measures used in some of the previous studies might not be applicable across all industries (Heras et al, 2002; Beattie & Sohal, 1999).

Summary

In summary, Training and Management Commitment would provide the most leverage during implementation due to their connection to all of the other implementation activities. A recommendation is to emphasize educating the workforce about the benefits of implementing the quality management system prior to and during the implementation

process. The training should encompass the big picture rationale. Selecting a business performance measure before initiating the implementation activities to serve as a baseline will enable management to maintain focus on the benefit of the system. A portfolio of training methods should be part of the education and awareness campaign. Key management personnel involvement in the education and awareness campaign about the change in the quality management system, will capitalize on the synergy between the implementation activities. Management involvement will illustrate the importance of the new system to the organization. Also management will be able to gauge the pulse of the workforce from firsthand knowledge.

External Consultants had the least influence on the implementation and the other activities and, as a result, should be used selectively. The research confirmed that the organization's motivation for seeking certification has an impact on both the implementation activities and the system performance while company size made little difference in how the certification was undertaken. Also, the non-manufacturing organizations behaved differently.

A predictive model will likely involve a more complex set of variables related in a non-linear relationship. A significant connection was found between documentation system implementation and process focus. To realize the most benefit from the system improvements, targeting process focus will also impact the corrective action system performance. Operating Costs and Sales Increase were robust across all of the environmental factors and were the most appropriate to measure system performance.

Benefits of This Research

This research examined the interaction of the process and outcomes from quality management system certification. The benefits of the research will be fourfold. The survey and data highlighted the interaction and utility of steps in the ISO 9001 certification process. The study also provided an analysis of environmental factors affecting management system certification, including industry, motivation, and size. An analysis and review of the organizational performance measures that are most appropriate for use with the quality management system to show impact on business results was conducted.

Finally, the research explored the connection between the components of the process used to gain ISO 9000 certification of an organization's quality management system and the business results. New organizations are seeking ISO 9000 certification each year with no decrease in the rate of new certifications occurring. The knowledge gained from this research will enable organizations seeking certification to prioritize and focus their resources on areas that will provide the most benefit. This will help organizations efficiently implement quality management systems and provide guidance to quality managers for customizing their approach to quality system certification.

Limitations of this Research

This research has limitations due to the size of the sample analyzed. The number of respondent to the survey was small compared to the population, however the number of respondents (150) and the population of ISO 9001:2000 certificates issued (951,486); result in an 8.87 confidence interval at the 95% confidence level so that valid conclusions can be drawn from the data. The generalization of the data could be limited and should be

revalidated with duplicate studies. Future studies could employ methods such as pre-survey notifications and reminder notifications or rewards for taking the survey to encourage a high participation level. The survey was distributed online via the Quality Digest e-mail newsletter and The Benchmarking Exchange e-mail distribution. Other distribution vehicles might have a different subscriber base however this community represents a good cross section of the quality community and non-practitioners.
Also, due to the sample size, the number of companies from each industry was small. Forty industry classifications were listed on the drop down pick list to select from. There were not enough respondents from each industry in the data set to draw significant conclusions based on the industry classification. The industry classifications were therefore collapsed into just two categories: manufacturing and nonmanufacturing during the data analysis so that statistically significant conclusions could be made. Future research would involve a sample targeted at specific industries to conduct a detailed analysis of industry classifications.

Limitations in the performance indicator area are related to the use of ROA which was determined to be statistically valid but much more needs to be discovered about its relationship the implementation activities. A larger sample size would enable additional factors to be introduced into the equation and analysis of their interactions. The ROA is a macro level indicator which is used by executives and financial managers, understanding its relationship to working level performance measures would be more beneficial for quality managers. The respondents rated a list of performance indicators on their usefulness developed from a literature review and panel of experts, a free text field would have allow respondents to submit a measure that was not on the list.

A research design limitation is the assumption that motivation and corporate culture of the entire organization are homogenous such that all parts behave the same way and have responded similarly to the implementation effort. Sub-cultures typically exist in parts of a company so that a single data point from each company could be replaced with a sample from the company. A focus group might be convened to discuss and elicit a consensus answer to the survey. A company sample might be consolidated or multiple entries entered separately.

Other assumptions are related to the time frame the data was collected. It is assumed that since there was no significant difference between the recently certified companies and those which had been certified for many years, that the opinions did not change over time.

Finally, this study limited the quality management system to the one described by ISO 9000. Other quality management systems exists with different components and potentially different implementation successes. ISO 9000 was chosen because it is recognized around the world and has been widely used.

Further Research

Areas of study to continue this research are to focus on very small businesses, process management, documentation system implementation, and training methodologies to enhance understanding of quality management processes.

The research did not show significant differences due to the size of the business in the rating of element performance. However, smaller businesses continue to be an area of interest for quality management. The global recession of 2008 – 2009 has shown that

larger businesses will not be quick to hire employees until long after an economic recovery so that economic growth will likely take place in smaller businesses. Businesses of fifty employees or less would benefit from more study due to their increasing significance in the global supply chain. Counterfeit or poor quality components hidden inside the subsystem of a major manufacturer can have a bullwhip effect. Implementing and maintaining an effective quality management system is an imperative for small businesses.

Other areas for research are to look into the nuances of documentation systems to understand how this area can be implemented to provide the most benefit for a quality management system. Documentation system implementation was correlated with training and with useful procedures, so exploring the interaction between these three system elements will be worthwhile. Keeping the documentation up to date is an area of concern all for implementers of management systems. Advances in information technology continue to change the way quality objectives, work instructions, and policies are deployed and updated throughout the work environment. Therefore, capturing knowledge and lessons learned for continuous improvement must be applied to keep pace. The use of technology to dynamically capture and update system documentation might be employed.

The newest version of the ISO 9000 standard emphasizes organizational efforts in the areas of continuous improvement and customer satisfaction. The implementation of tools, such as Six Sigma, can be leveraged to gain maximum benefit from the quality management system implementation.

Some environmental differences were noted between manufacturing and non-manufacturing organization. Future research might involve a larger sample to conduct a detailed analysis of industry classifications.

References

Aarts, F.M., & Vos, E. (2001). The impact of ISO registration on New Zealand firms' performance: A financial perspective. *The TQM Magazine, 13*(3), 180.

American Society for Quality (2000). *Quality Management Systems – Fundamentals and Vocabulary.* Milwaukee, Wisconsin: Quality Press.

Arbuckle, G. (2004). *A comparative study of selected measures of performance of organizations before and after obtaining ISO 9000 certification as compared to the S and P 500 Index* (Doctoral dissertation). Indiana State University, Terre Haute, IN.

Baldrige National Quality Program. (2009). Retrieved 2009 from http://www.baldrige.nist.gov/

Bandyopadhyay, J.K. (2005). A model framework for developing industry specific quality standards for effective quality assurance in global supply chains in the new millennium. *International Journal of Management*, *22*(2), 294.

Beattie, K.R., & Sohal, A.S. (1999). Implementing ISO 9000: A study of its benefits among Australian organizations. *Total Quality Management, 10*(1), 95.

Bell, M., & Omachonu, V. (2007, May). Determinants of success in ISO 9000 implementation for small businesses in the electronics industry: A methodology design. IAMOT 2007: 16th *International Conference on Management of Technology*, Miami Beach, FL.

Bendell, T., & Boulter, L. (2004). ISO9000:2000 A survey of attitudes of certified firms. *International Small Business Journal, 22*(3), 295-316.

Berry, R. (1996). *An investigation of the relationship between world-class quality system components and performance* (Doctoral dissertation). University of North Texas, Denton, TX.

Bravener, L.C. (2005). AS9003: An aerospace standard for the little guy. *Quality Progress, 38*(3)

Brealey, R.A. (2003). *Fundamentals of Corporate Finance.* New York: McGraw-Hill.

Briscoe, J. A., Fawcett, S. E., & Todd, R. H. (2005). The implementation and impact of ISO 9000 among small manufacturing enterprises. *Journal of Small Business Management, 43*(3), 309-330.

Burrill, C., & Ledolter, J. (1999). *Achieving Quality Through Continual Improvement*. Hoboken, NJ: John Wiley & Sons.

Buttle, F. (1997). ISO 9000: Marketing motivations and benefits. *International Journal of Quality & Reliability Management*, *14*(9), 936-947.

Callaghan, N., & Schnoll, L. (1997) ISO 9000 for small companies *Quality Digest*. Retrieved 7/11/2006 from: http://www.qualitydigest.com/aug97/html/cover.html

Carlsson, M., & Carlsson, D. (1996). Experiences of implementing ISO 9000 in Swedish industry. *International Journal of Quality & Reliability Management, 13*(7), 36-47.

Chara, R. (2004). *Profitable Growth is Everyone's Business: Ten Tips You Can Implement Monday Morning.* New York, NY Crown Business.

Corbett, C. J., Montes-Sancho, M. J, & Kirsch D. A. (2005). The financial impact of ISO 9000 certification in the United States: an empirical analysis management. *Science, 51*(7), 1046.

DataMonitor (2006). *Global Consumer Electronics Industry Profile* June 2006. Retrieved 2/10/2007 from: www.datamonitor.com

Douglas, A., Coleman, S., & Oddy, R. (2003). The case for ISO 9000. *The TQM Magazine*, 15 (5) 316-324.

Dixon, J. (1996). *Total Quality Management in ISO-9000 registered organizations: An empirical examination of the critical characteristics associated with levels of financial performance* (Doctoral dissertation). Florida State University, Tallahassee, FL.

Djerdjouri, M. (2004). National quality and business excellence awards in a developing country: The Fiji national quality award. *The TQM Magazine, 16*(2), 120- 124.

Ebrahimpour, M., Wither, B.E., & Hikmet, N. (1997). Experiences of US- and foreign-owned firms: A new perspective on ISO 9000 implementation. *International Journal of Production Research, 35*(2), 569-576.

Faull, N., & Fleming, P. (2005). Turning intentions into outcomes: A quick scorecard to guide implementation. *Measuring Business Excellence, 9*(3), 5.

Gliem, J., & Gliem, R. (2003, October). Calculating, interpreting, and reporting cronbach's alpha reliability coefficient for likert-type scales. *Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education*, Ohio State University, Columbus, OH.

Goldratt, E. M. (1994). *Theory of Constraints.* Croton-on-Hudson, NY: North River Press.

Griswold, H., & Prenovitz, S. (1993) How to translate strategy into operational results. *Business Forum, 18*(3), 5.

Groves, R. M , Fowler, F.J, Couper, M.P, Lepkowski , J.M, Singer, E, & Tourangeau, R. (2004). *Survey Methodology*. Hoboken, NJ: John Wiley & Sons.

Gusatfsson, R., Klefsjo, B., & Granfors-Wellemets, U. (2001). Experiences from implementing ISO 9000 in small enterprises – a study of Swedish organizations. *The TQM Magazine, 13*(4), 232- 246.

Gyani, G. J. (2007, August, 7). *Inside Standards.* Retrieved from Quality Digest: http://www.qualitydigest.com/inside/standards-article/crisis-credibility

Han, S. (2000). *The effects of ISO 9000 registration efforts on Total Quality Management practices and business performance* (Doctoral dissertation). University of Rhode Island, Kingston, RI.

Harris, M. E. (1987). Understanding corporate culture: An experiential exercise. *Journal of Management Education*, 11;140,140- 142.

Harrison, M. (2000). *The nature, effects, and management of cues in ISO 9000 quality-managed organizations* (Doctoral dissertation). Florida State University, Tallahassee, FL.

Haversjo, T. (2000). The financial effects of ISO 9000 registration for Danish companies. *Managerial Auditing Journal, 15*(1/2), 47-52.

Heras, I., Casadesus, M., & Dick, G. P.M. (2002). ISO9000 certification and the bottom line: A comparative study of the profitability of Basque region companies. *Managerial Auditing Journal, 17*(1/2), 72-78.

Hwang, I. & Chung-Li, C. (2004). A systematic approach to optimizing business processes beyond ISO 9000: A Taiwanese case study. *International Journal of Management, 21*(3), 349-360.

Jaffrey, S.H. (2004). ISO 9001 made easy. *Quality Progress, 37*(5),104.

Jodoin, C. (1998). Getting started with ISO/QS 9000 requirements. *Printed Circuit Design, 15*(6), 46.

Johannsen, C. G. (1996). ISO 9000 A managerial approach. *Library Management, 17*, 14- 24.

Knight, F. (1997). *A study of the benefits of ISO 9000 quality standards application as related to the state of quality management maturity in organizations* (Doctoral dissertation). University of Alabama in Huntsville, Huntsville, AL.

Kristy, J. (1994). Conquering financial ratios: The good, the bad and the who cares. *Business Credit, 96*(2), 14.

Laframboise, K. (2002). *An empirical study of the relationship between quality practices and business performance excellence in central Canada* (Doctoral dissertation). Concordia University, Montreal, Quebec, Canada.

Lapointe, L., & Rivard, S. (2006). Getting physicians to accept new information technology: Insights from case studies. *Canadian Medical Association Journal, 174*(11), 1573.

Lee, K., & Palmer, E. (1999). An empirical examination of ISO 9000 registered companies in New Zealand. *Total Quality Management*, *10*(6), 887.

Liebesman, S. (2005). Mitigate SOX risk with ISO 9001 and 14001. *Quality Progress, 38*(9), 91-93.

Mann, R., & Kehoe, D. (1994). An Evaluation of the effects of quality improvement activities on business performance. *International Journal of Quality & Reliability Management, 11*(4) 29-44.

McLachlan, V. N. (1996). In praise of ISO 9000. *The TQM Magazine, 8*, 21-23.

Mergent Online (September 2009). Retrieved from Mergent Online: http://www.mergentonline.com.ezproxy.apollolibrary.com/compsearch.asp

Morf, D. (2000). *ISO 9000 and the CPA: A current assessment of progress in a key area of assurance services* (Doctoral dissertation). University of Mississippi, Oxford, MS.

Morris, P. (2003). *Quality and competitive advantage: An empirical study of ISO 9000 adoption in the electronics industry* (Doctoral dissertation). Texas Tech University, Lubbock, TX.

Morris, P. (2006). ISO 9000 and financial performance in the electronics industry. *Journal of American Academy of Business*, *8*(2), 227.

Mumma, G. (2000). *The impact of ISO 9000 standards on United States agribusiness and trade* (Doctoral dissertation). Mississippi State University, Starkville, MS.

Murakami, R. (1994). How to implement ISO 9000. *CMA Magazine, 68*(2), 18.

Paden, R. (2003). *ISO 9000 implementation in the chemical industry* (Doctoral dissertation). Northcentral University.

Peterson, A. (2004). *Making a case for challenging the current and future efficacy of the Plan, Do, Check, Act (PDCA) quality cycle: The foundation of quality management systems* (Doctoral dissertation). University of Minnesota.

Powers, L. (2003). *The velocity of change in business today: Analysis of a defined method of implementing ISO 9000 standards in selected Southern California companies* (Doctoral dissertation). Pepperdine University, Malibu, CA.

Quazi, H.A., & Padibjo, S.R. (1998). A journey toward total quality management through ISO 9000 certification – A study on small- and medium-sized enterprises in Singapore. *International Journal of Quality & Reliability Management, 15*(5), 489-508.

Schonberger, R. (1982). *Japanese manufacturing techniques: Nine hidden lessons in simplicity.* New York: Simon & Schuster.

Singels, J., Ruel, G., & van de Water, H. (2001). ISO 9000 series certification and performance. *International Journal of Quality & Reliability Management, 18*(1), 62-75.

Simmons, B., & White, M. (1999). The relationship between ISO 9000 and business performance: Does registration really matter? *Journal of Managerial Issues, 11*(3), 330-343.

Skrabec, Q. (1999). *ISO 9000 as a quality assurance system: A theoretical framework* (Doctoral dissertation). University of Toledo, Toledo, OH.

Smith, B. (1994). A proven path to ISO 9000 registration. *Industrial Distribution, 83*(7), 50.

Sun, H. (2000). Total quality management, iso 900 certification and performance improvement. *International Journal of Quality and Reliability Management, 17*(2), 168-179.

Sun, H., & Cheng, T. (2002). Comparing reasons, practices and effects of ISO 9000 certification and TQM implementation in Norwegian SMEs and large firms. *International Small Business Journal, 20*(4), 421-442.

Tague, N. (1994). Using ISO 9000 to drive total quality. *Managing Service Quality*, 4(1) 24- 27.

Tannock, J., & Brown, H. (2004). Consumers and quality management standards. *Consumer Policy Review, 14*(6), 162-168.

Terlaak, A. (2002). *Exploring the adoption process and performance consequences of industry management standards: The case of ISO 9000* (Doctoral dissertation). University of California, Santa Barbara, Santa Barbara, CA.

Terziovski, M., Samson, D., & Dow, D. (1997). The business value of quality management systems certification: Evidence from Australia and New Zealand. *Journal of Operations Management, 15*, 1-18.

Thonhauser, T. (2005). *Factors that relate to the successful implementation of ISO 9000 in education: A comparison between the United States and England* (Doctoral dissertation). Pennsylvania State University.

Tsiotras, G., & Gotzamani, K. (1996). ISO 9000 as an entry key to TQM: The case of Greek industry. *International Journal of Quality and Reliability Management, 13*(4), 64-76.

van den Heuvel, J., Boger, J., Does, R., van Dijk, S., & Berg, M. (2006). Quality mangement does it pay off. *Quality Mangement in Health Care*, 15(2)137- 149.

West, J. (2005). Getting and keeping top managers involved. *Quality Progress*, 38(10) 76-79

Williams, J. (2003). *Motivating factors and perceived benefit successes in implementing the ISO 9002 registration process* (Doctoral dissertation). Walden University.

Wilcox, M. (2004). Pridiction and prgamatism of Shehart's theory of statisical control. *Management Decision , 42*(1), 152- 165.

Zhang, G. (1999). Beyond ISO certification – A China experience. *Managerial Auditing Journal*, 14(2) 75- 78.

Appendix A

Management System Implementation and Outcome Assessment

Thank you for taking the time to participate in this survey to better understand the determinants of success in ISO 9000 Implementation. This survey should take less than 15 minutes to complete. We will keep individual responses confidential and will not identify you or your company in relation to any specific response. This survey has three main sections. The first section is a profile of your organization/company. The second section concerns the quality system Implementation steps. The third section is an Outcomes section about the success your organization/company achieved.

Organization/company name	
Title	
Organization department (i.e. Quality, Human Resources, Accounting, etc.)	

a. Number of employees:

( ) 0 - 50 ( ) 51 - 100 ( ) 101 - 500 ( ) 501 - 1000 ( ) 1000+

b. Industry Classification

NAICS Code	Title	√
11	Agriculture, Forestry, Fishing and Hunting	
21	Mining	
22	Utilities	
23	Construction	
31	Manufacturing	
42	Wholesale Trade	
44	Retail Trade	
48	Transportation and Warehousing	
51	Information	
52	Finance and Insurance	
53	Real Estate and Rental and Leasing	
54	Professional, Scientific, and Technical Services	
55	Management of Companies and Enterprises	
56	Administrative and Support /Waste Management Services	
61	Educational Services	
62	Health Care and Social Assistance	
71	Arts, Entertainment, and Recreation	
72	Accommodation and Food Services	
81	Other Services (except Public Administration)	
92	**Public Administration**	

c. Are you now ISO 9000 Certified?

( ) Yes ( ) No

d. If yes, what year did you start working towards certification_____

e. What year did you become certified_____

f. What was your primary or most important reason for seeking certification?

( ) Customer Request ( ) Competition ( ) To Reduce Costs ( ) Management Initiated ( ) Other

Quality System Implementation Steps

The following questions relate to your organization's experience while seeking ISO 9000 certification of your quality management. Answer the questions below about the steps taken to gain quality system certification by placing a check (√) below the appropriate item.

1. Management commitment and buy-in for ISO 9000 certification was evident

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Don't Know/NA
( )	( )	( )	( )	( )	( )

2. How much did your organization use external consultant(s) to assist with quality system implementation?

Not Used	Very little use	Intermittent use	Extensive use	Don't Know
( )	( )	( )	( )	( )

To what degree were the following items implemented as part of your ISO 9000 certification effort? Place a check (√) in column that best describes your implementation experience.

	Not Done	Very Small Degree				Very Large Degree
	0	1	2	3	4	5
3. Everyone was made aware of the coming change and introduced to the benefits of an ISO 9000 registered management system						
4. Established commitment throughout the company						
5. Conducted a pre-assessment audit						
6. Created a functional quality system manual and quality policy						
7. Established a workable documentation system						
8. Provided employees with training on the quality management system						
9. Constructed friendly draft procedures and documented current processes						
10. Implemented new procedures						
11. Conducted executive level system reviews						

12. Please provide additional comments on how this process was implemented:

Management System Element

Please indicate below the performance level your quality management system outcomes by placing a (√) in the appropriate column.

	Don't Know/NA	Poor process outcomes				Best in class performance with sustained results
	0	1	2	3	4	5
13. Documented Procedures/ Control of Documents						
14. Periodic Management Review						
15. Closed Loop Corrective Action System						
16. Process Focus & Control of Processing						
17. Customer Focus						

18. Please provide additional comments on your process outcomes:

VITA

Michael Albert Bell graduated from Lincoln High School in Bloomington, Minnesota and earned a Bachelor of Science in Industrial Engineering from Northwestern University in Evanston, Illinois. He worked as an industrial engineer in the electronics manufacturing industry for ten years before initiating graduate coursework at the University of Central Florida. He graduated with a master of science in engineering management from the University of Central Florida. He was admitted to the inaugural class of the University of Miami Space Coast Ph.D. Program and earned a doctorate in Industrial Engineering in May 2011.