Title: The Impact of Contextual Factors on the Efficacy of ISO 9000 Adoption

Abstract:

This study investigates the importance of contextual factors on the efficacy of ISO 9000 adoption. We explore the role of various contextual factors at the firm-level (i.e., technology intensity, labor productivity, and labor intensity) and industry-level (i.e., industry efficiency level, industry competitiveness, industry sales growth, and industry ISO 9000 adoption level) that potentially impact the efficacy of ISO 9000 adoption. We carry out a hierarchical linear modeling (HLM) analysis based on objective financial data from 438 U.S. manufacturing firms. The results show that firms with low technology intensity, low labor productivity and high labor intensity reap more benefit from ISO 9000 adoption. Firms in industries with low efficiency levels, high competition, high sales growth and low ISO 9000 adoption levels also obtain more benefit from the adoption. Our research provides supporting evidence for the context-dependent proposition of ISO 9000 adoption. Given the significant costs and resources involved, it is crucial for operations managers to assess to what extent ISO 9000 might benefit their performance before embarking on the implementation process.

Keywords: ISO 9000, financial performance, contextual factors, hierarchical linear modeling

1. Introduction and Research Background

The ISO 9000 series[1] provides arguably one of the most widespread quality management system (QMS) approaches. According to the ISO (International Organization for Standardization), by the end of 2010, ISO 9000 had been adopted by more than one million facilities in 178 countries, of which 36,632 certifications were in North America, 530,722 in Europe, and over 428,755 in the Far East (ISO, 2011). A widespread criticism of ISO 9000 is the administrative burden and the need for extensive supporting documentation, which is both time consuming and costly (McGuire and Dilts, 2008). Dunn and Bradstreet Information Services (1996) in the U.S. reported that the average implementation cost of ISO 9000 was $409,000 for large firms. This leads to uncertainty about whether a firm should make a significant investment to implement ISO 9000 and whether the employed resources lead to quality improvement (Sroufe and Curkovic, 2008).

Proponents claim that ISO 9000 certification benefits companies with a direct impact on product costs and improves financial performance (e.g., Corbett et al., 2005; Levine and Toffel, 2010; Sharma, 2005). The financial performance improvement is expected to arise from enhanced operational efficiency, which translates directly into cost reductions (Terlaak and King, 2006). Another expected source of performance improvement is an increase in revenue as ISO 9000 certified firms are able to access new customers or markets (e.g., Singh et al., 2011; Sroufe and Curkovic, 2008).

However, there is also empirical evidence suggesting that improvements in financial performance as a result of ISO 9000 certification are questionable. Naveh and Marcus (2005) state that while applying the ISO 9000 standard may lead to operational benefits, it does not necessarily lead to improved financial performance. Docking and Dowen (1999) found that the stock prices of large firms did not respond to announcements of first ISO 9000

[1] In the remainder of the article we refer to ISO 9000 as a family of quality certifications because different versions of ISO 9000 certification were introduced in the period from which we extracted data for analysis (i.e., 1990 to 2004).

certification. Morris (2006) found that the financial performance of ISO 9000 certified electronics manufacturer did not outperform their non-certified counterparts.

The effectiveness of ISO 9000 is highly controversial (McGuire and Dilts, 2008) and thus further research on the standard is needed. Some researchers suggest that the inconsistent findings about ISO 9000 adoption might be due to differences in contextual factors (e.g., Benner and Tushman, 2002; Sousa and Voss, 2008). A number of researchers have also suggested the need to consider in more depth the influence of contextual factors within operations management (OM) (e.g., Sila, 2007; Sousa and Voss, 2008; Swink and Jacobs, 2012; Zhang et al., 2012). With the widespread adoption of ISO 9000 worldwide, it is increasingly important for OM researchers to examine the interrelationships among ISO 9000 adoption, firm performance, and contextual factors.

The objective of this paper is to answer the following research question: *Under what contextual factors is the efficacy of ISO 9000 adoption stronger?* Operations managers need to assess whether the adoption of a specific OM practice is an appropriate fit with the contextual factors. They should not simply take an institutional response and follow others in adopting a standard set of operational practices, but analyze the contexts of their organization and implement operational practices that best suit their needs.

From an OM perspective, contextual factors have been categorized as strategic goals, structural contingencies, and environmental/institutional factors (Ketokivi and Schroeder, 2004; Sousa and Voss, 2008). This study extends previous research by studying various contextual factors at the *firm-level* (i.e., technology intensity, labor productivity, and labor intensity) and *industry-level* (i.e., industry efficiency level, industry competitiveness, industry sales growth, and industry ISO 9000 adoption level).

2. Hypotheses Development

2.1 Firm-level contextual factors

Firm technology intensity. Benner and Tushman (2002) identify that ISO 9000 adoption is associated with an increase in incremental innovations that build on existing firm knowledge, but a decrease in exploratory innovations that need a high level of research and development (R&D) expenditure. As a result, we argue that ISO 9000 is more suitable for companies with lower levels of technology intensity, as their products and processes are likely to be standardized, with incremental innovations being the norm (Benner and Tushman, 2002). In such a stable environment, a highly structured QMS is likely to be more effective. On the other hand, for organizations operating in more technologically dynamic environments, such as consumer electronics sectors, production processes change frequently. Frequent revisions of the process control procedures and the associated quality documentation are required, leading to increased costs. The measurement of technology intensity is related to R&D expenditure (Wakelin, 2001). Firms with higher R&D expenditure relative to sales tend to be technologically intensive, and it is used as a proxy for technology intensity and represents a firm-level contextual factor.

H1: Firms with low technology intensity obtain more benefit from ISO 9000 adoption than firms with high technology intensity.

Firm labor productivity. Rogers et al. (2007) suggest that suppliers with lower initial levels of productivity have relatively more room for improvement in a supplier development program. Akhavein et al. (1997) find that less efficient firms gain significantly higher efficiency improvements after a merger. In a study of the relationship between exporting and firm performance, Park et al. (2010) observe that firms experience a higher degree of productivity improvement when they have lower initial productivity levels. Based on the same rationale, less productive firms that adopt ISO 9000 should have more room for improvement compared with more productive firms. Labor productivity is measured by a firm's operating profit (before depreciation and tax) relative to its number of employees.

H2: Firms with low labor productivity obtain more benefit from ISO 9000 adoption than firms with high labor productivity.

Firm labor intensity. An increase in labor intensity implies more reliance on the competency and skills of the workforce. Firms that are labor-intensive run the risk of generating higher levels of defects and rejects due to a reliance on the skills and capability of the workforce (Hendricks and Singhal, 2000). As a production system becomes more dependent on people, the need for a formalized process to manage quality becomes increasingly important. Introducing process standardization through ISO 9000 could help high labor-intensive firms to better control their processes. However, for a low labor-intensive firm, there is less room for further improvement in the QMS because it has a higher level of automation (Hendrick and Singhal, 2000).

H3: Firms with high labor intensity obtain more benefit from ISO 9000 adoption than firms with low labor intensity.

2.2 Industry-level contextual factors

Industry efficiency level. We argue that some industries are more advanced and efficient than others in the adoption of OM techniques. For example, TQM, advanced quality assurance procedures (e.g., GMP), and supply base rationalization have been widely adopted in highly efficient industries such as the medical device industry (Dixon et al., 2006). However, in less efficient industries, such as pulp and paper, advanced OM techniques are less commonly applied (Zobel, 1984). Based on the financial data retrieved from publicly listed companies, *Fortune*'s (2009) analyses indicate that the medical device industry is highly efficient in terms of ROA, while the pulp and paper industry is one of the most inefficient sectors. Accordingly, firms in the pulp and paper industry, being less well organized in their OM practices, are likely to benefit more from ISO 9000 adoption than firms in the medical device industry. For ISO 9000 certified firms in less efficient industries, the opportunity for improvement is likely to be more significant since they start from a lower base in terms of the potential to improve performance.

H4: Firms in less efficient industries obtain more benefit from ISO 9000 adoption than firms in more efficient industries.

Industry competitiveness. Industry competitiveness is also a contextual factor that potentially impacts the efficacy of ISO 9000 (Das et al., 2000). In highly competitive industries, the greater the number of competitors, the more intense is the rivalry as the spoils of the market must be divided among a greater number of firms (Melville et al., 2007). Given the emphasis of ISO 9000 on ongoing process improvement, certified firms are better positioned to cope with higher levels of competition by reducing manufacturing costs, streamlining management structures and improving product quality. The skills and knowledge developed in introducing process innovations during adoption provide the firm with a competitive edge, which remains long after being certified (Levine and Toffel, 2010). On the contrary, less competitive industries tend to be dominated by a limited number of larger organizations, and there is less incentive for firms to seek ISO 9000 certification. The Herfindahl index is used to measure industry concentration (level of competitiveness) (Hendricks and Singhal, 2008). The higher the value of the index, the more concentrated (less competitive) is the industry.

H5: Firms in highly competitive industries (as measured by the Herfindahl index) obtain more benefit from ISO 9000 adoption than firms in less competitive industries.

Industry sales growth. Another factor to consider is that high growth markets over time encourage new entrants (Aaker and Day, 1986). These new firms tend to be less well known and need to establish themselves. ISO 9000 certification becomes more important for these new entrants since it provides a signaling effect to the market indicating that they are taking quality seriously. Ferguson (1996) argues that many organizations take a conservative approach to industrial buying, and this leads them to solicit proposals from only ISO 9000 certified firms. New entrants without ISO 9000 certification are likely to be screened out from the potential supplier lists. Thus, ISO 9000 adoption becomes a more critical "entrance requirement" for potential customers.

H6: Firms in industries with high sales growth obtain more benefit from ISO 9000 adoption than firms in industries with low sales growth.

Industry ISO 9000 adoption level. Initially, ISO 9000 certification was seen as a way for firms to differentiate themselves from competitors as an order-winning criterion (Hill, 1993). Cole (1998) suggests firms may make ISO 9000 their primary instrument for signaling their quality credentials to their customers. As the standard has become a requirement and increasingly common in most industry sectors, organizations may be tempted to only pay "lip service" to the implementation process and adopt the standard in a superficial way (Dick, 2000). The certification process becomes an end in itself, rather than a means to foster good quality practices. The implementation of ISO 9000 is dissociated from the daily organizational activities. This leads to lower compliance with the standard, resulting in a negative impact on financial performance.

H7: Firms in industries with low ISO 9000 adoption levels obtain more benefit from ISO 9000 adoption than firms in industries with high ISO 9000 adoption levels.

3. Methodology

3.1 Data collection

We focus on manufacturing firms with Standard Industry Classification (SIC) codes ranging from 2000 to 3999. We extracted ISO 9000 certified firms (with at least one certified plant) and their years of certification from the *Quality Digest* and *Who's Registered* databases. Since each sample firm could have multiple plants/facilities certified, we focused on the first ISO 9000 certification (Corbett et al., 2005). After compiling the data from the online databases and from Standard and Poor's COMPUSTAT, we identified 1,001 publicly listed ISO 9000 certified manufacturers. We analyze the sample firms' performance three years after they obtained certification (year 3), because the valid period of each certification is three years. Year 0 denotes the year of formal ISO 9000 certification.

3.2 Matching to control firms

We apply HLM analysis to assess whether the proposed firm- and industry-level contextual factors affect the long-term impact of ISO 9000 adoption on financial performance. The dependent variable is the adopting firms' post-certification ROA in year 3 minus the industry median ROA of the same two-digit SIC code in year 3.

As the average preparation time to pass the certification audit is 6-18 months (Corbett et al., 2005), we use sample firms' ROA in year -2 (i.e., two years before certification) to match non-ISO 9000 certified firms. We match each sample firm with a portfolio of non-ISO 9000 certified firms based on the following criteria and steps:

Step 1. At least a two-digit SIC code, 50%-200% of firms' total assets, and 90%-110% of ROA in year -2.

Step 2. If no non-ISO 9000 certified firm is matched in Step 1, we use at least a one-digit SIC code, 50%-200% of firms' total assets, and 90%-110% of ROA.

Step 3. If no non-ISO 9000 certified firm is matched in Step 2, we use 50%-200% of firms' total assets and 90%-110% of ROA as the matching criterion.

The above steps are mainly based on Barber and Lyon (1996)'s event study guidelines and we add firms' total assets as an additional criterion (Hendrick and Singhal 2008). The initial sample list consisted of 1,001 active ISO 9000 certified firms covering certification years from 1990 to 2008. However, 319 out of the 1,001 firms did not have financial data in the base year (i.e., *t*-2) for possible matching (e.g., firms were not yet listed in the year of ISO 9000 certification), leaving 682 firms. We further excluded 108 firms that did not have the complete data set required over the six-year period. The remaining 574 firms were matched based on the above steps. The number of sample firms from each step was as follows: Step 1 - 354 (61.7%), Step 2 - 202 (35.2%), and Step 3 - 4 (0.7%). We discarded 14 (2.4%) observations that could not be matched with any non-ISO 9000 certified firms, leaving 560 sample pairs. However, 122 of these matched firms did not disclose the number of employees, R&D expenses, or information on the ISO 9000 version. Therefore, the number of observations for our HLM analysis dropped to 438. Since the year of ISO 9000 certification of our sample firms ranges from 1990 to 2004 and we need performance data from year -2 to year 3 for analysis, we examine performance data covering the period 1988 to 2007. Table 1 shows the distribution of the certification year and industry of the sample firms.

[Table 1 about here]

3.3. Control variables in the HLM analysis

We add the following control variables in the HLM analysis:

- *Firm Size*: The natural logarithm of a firm's total assets.
- *Pre-certification ROA (industry adjusted)*: The ratio of a firm's operating profit to its total assets minus the industry median ROA at year -2.
- *Non-ISO 9000 Certified firms' ROA Change*: The median change in non-ISO 9000 certified firms' ROA (i.e., control firms matched in Section 3.2) from year -2 to year 3.
- *Industry Size*: The natural logarithm of all the firms' total assets in the same industry (two-digit SIC code).
- *ISO 9000 Version's Dummy*: 1994 version as 0 and 2000 version as 1
- *Single-plant Dummy*: Multiple-plant as 0 and single-plant firm as 1

ISO 9000 adoption is a plant-level certification, while the performance indicators are at the firm-level. We thus distinguish single-facility firms from multiple-facility firms and examine the impact of such a distinction (Levine and Toffel, 2010). We checked the adopting firms' annual reports in the year of ISO 9000 adoption for information on their facilities.

3.4. Calculation of contextual factors

The calculations of the contextual factors are as follows:

- *Firm Technology Intensity*: The ratio of a firm's R&D expenses to its sales.
- *Firm Labor Productivity*: The ratio of a firm's operating profit (before depreciation and tax) to its number of employees.
- *Firm Labor Intensity*: The ratio of a firm's employee number to its total assets.
- *Industry Efficiency Level*: Industry median ROA (two-digit SIC code).
- *Industry Competitiveness*, or the Herfindahl index: The sum of squared market shares of the firms in an industry.
- *Industry Sales Growth*: The yearly percentage change in industry sales.
- *Industry ISO 9000 Adoption Level*: The sales-weighted percentage of ISO 9000 certified firms in its industry. The adoption level represents the level of external pressure, and large firms are likely to have a greater influence than small ones.

Table 2 presents the correlation coefficients and the descriptive statistics of all the variables. To verify the independence of each variable, we checked their variance inflation factor (VIF) based on the ordinary least squares (OLS) method, and the values are between 1.067 and 2.738. The results suggest that multicollinearity is not an issue in our research as the VIF values are below the threshold of 5. We also conducted residual analysis. The Durbin-Watson statistic is 1.883, which falls between the range of 1.78 and 1.90 for a sample with a size close to 440 and 14 predictors. This result suggests that the autocorrelation among the residual values is not significant ($p > 0.05$) (Savin and White, 1977).

[Table 2 about here]

4. Results

We conducted HLM analysis to examine the impact of the two-level (firm and industry) contextual factors on abnormal changes in sample firms' post-certification ROA (industry adjusted). Table 3 presents the results of the HLM analysis. We developed four models in our analysis. The first model is the base model that includes only the intercepts. The other three models are control, firm-level, and industry-level models. The tests of our hypotheses are based on the final model (i.e., industry-level model). The changes in chi-square for all three models are significant at the 1% level, suggesting that the models are well specified. The changes in the R^2 value are 29.45%, 7.07%, and 11.15%, for the control, firm-level and industry-level models, respectively.

[Table 3 about here]

In the final model (i.e., industry-level model), firm size, pre-certification ROA and ISO 9000 version's dummy are highly significant ($p < 0.01$), whereas the single-plant dummy is moderately significant ($p < 0.05$). The non-ISO 9000 certified firms' ROA change and the industry size have no significant impact on firm post-certification ROA.

For the firm-level contextual factors in the final model, firm technology intensity is negatively related to post-certification ROA ($p < 0.01$), suggesting that high technology-intensive firms reap less benefit from ISO 9000 adoption than low technology-intensive firms. Therefore, H1 is supported. Firm labor productivity shows a significant negative relationship with post-certification ROA ($p < 0.01$), implying that more efficient firms obtain less benefit from ISO 9000 adoption. H2 is supported. Firm labor intensity is positively related to post-certification ROA ($p < 0.01$), suggesting that high labor-intensive firms reap more benefit than low labor-intensive firms. H3 is supported.

For the industry-level contextual factors, we find that industry efficiency is negatively related to post-certification ROA ($p < 0.01$), indicating that firms operating in more efficient industries reap less benefit than firms in less efficient industries. H4 is supported. Industry competitiveness (measured by industry concentration) is negatively related to post-certification ROA ($p < 0.01$), suggesting that the more concentrated (less competitive) an industry is, the less likely are firms in the industry to benefit from ISO 9000 adoption. This finding supports H5. Industry sales growth is positively related to post-certification ROA ($p < 0.01$). This implies that the benefit of ISO 9000 adoption is significantly higher in high sales growth industries. This result supports H6. Finally, we find a significantly negative relationship between industry ISO 9000 adoption level and post-certification ROA ($p < 0.05$). This suggests that the benefit of ISO 9000 decreases when the adoption of ISO 9000 increasingly becomes a norm in an industry. Thus, H7 is also supported. The changes in the R^2 value in Table 3 show that the firm- and industry-level contextual factors account for 18.22% of the variance explained in post-certification performance.

5. Conclusion

Our findings may help operations managers determine whether they should implement process standards like ISO 9000 and whether they should require their suppliers to be certified for such standards. Clearly, some firms are under pressure from customers to adopt ISO 9000. Operations managers need to question the efficacy of such an approach. Should organizations require suppliers to be ISO 9000 certified if their suppliers are, e.g., highly technology-intensive, highly automated (low labor intensity), and in efficient industries in which high-quality requirements are already well embedded? Our research findings would suggest that this may not necessarily be a viable approach. We are concerned that such an approach may actually compromise some adopting firms' performance in the long run.

The findings of this study suggest that a one-size-fits-all approach to ISO 9000 certification may not ultimately lead to optimal outcomes. As pointed out by Zhang et al. (2012), there is a need to move beyond simply justifying quality practices and focus on a clear understanding of the contextual factors. This shift to refining our understanding of quality practices is supported by a number of studies (Das et al., 2000; Sila, 2007). Our results show that operations managers in different contextual environments need to think carefully about the likely performance benefits to be derived from ISO 9000 adoption for their organizations. The performance benefits and success of the ISO 9000 standard are dependent in part on the various contextual factors examined in our study. Therefore, practitioners should not simply follow other organizations by applying a standard set of institutionalized OM practices. They should analyze their firm and industry contexts and implement appropriate operational practices to achieve operational excellence.

Our findings need to be carefully interpreted due to the limitations associated with the research. Our sample consists of publicly listed manufacturing firms in the U.S. The impact of ISO 9000 on private firms or firms in the service sector could be quite different. Moreover, ISO 9000 certification is normally conducted at the plant level, while the financial data are available only at the firm level. Another potential problem is a large number of sample firms (n = 108) were excluded due to the unavailability of financial data from year -2 to year 3. We conducted a t-test to compare the industry-adjusted ROA performance (at year -2) between the final sample and the dropped sample, and we found no significant difference between the two sets (t = 0.559, p = 0.577).

Further studies on the potential impacts of contextual factors on other OM practices may help both academics and practitioners gain a deeper understanding of the effectiveness of these practices, such as lean manufacturing. Finally, future research on the impact of contextual factors on the efficacy of ISO 9000 certification could be conducted not only at the firm and industry levels, but also at the supply chain level. For example, the benefit of ISO 9000 certification might depend on the position of the certified firm in the supply chain.

Acknowledgements

We sincerely thank an Associate Editor and three anonymous referees for their support and many helpful comments throughout the review process. This research was supported in part by the UK ESRC grant RES-000-22-3638 and the Hong Kong Polytechnic University under Grant number B-Q26U.

References

Aaker, D.A., Day, G.S., 1986. The perils of high-growth markets. Strategic Management Journal 7 (5), 409-421.

Akhavein, J.D., Berger, A.N., Humphrey, D.B., 1997. The effects of megamergers on efficiency and prices: Evidence from a bank profit function. Review of Industrial Organization 12 (1), 95-139.

Barber, B.M., Lyon, J.D., 1996, Detecting abnormal operating performance: The empirical power and specification of test statistics. Journal of Financial Economics 41 (3), 359-399.

Benner, M.J., Tushman, M., 2002. Process management and technological innovation: A longitudinal study of the photography and paint industries. Administrative Science Quarterly 47 (4), 676-706.

Cole, R.E., 1998. Learning from the quality movement: What did and didn't happen and why? California Management Review 41 (1), 43-73.

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), 1046-1059.

Das, A., Handfield, R.B., Calatone, R.J., Ghost, S., 2000. A contingent view of quality management–the impact of international competition on quality. Decision Sciences 31(3), 649-689.

Dick, G., 2000. ISO 9000 certification benefits, reality or myth? The TQM Magazine 12 (6), 365-371.

Dixon, D., Eatock, J., Meenan, B.J., Morgan, M., 2006. Application of design of experiment (DOE) techniques to process validation in medical device manufacture. Journal of Validation Technology 12 (2), 92-100.

Docking, D.S., Dowen, R.J., 1999. Market interpretation of ISO 9000 registration. Journal of Financial Research 22 (2), 147-160.

Dunn and Bradstreet Information Services, 1996. The ISO 9000 Survey, Comprehensive Data and Analysis of Registered Companies in the United States and Canada. Irwin Publishing, Burr Ridge, Illinois.

Ferguson, W., 1996. Impact of the ISO 9000 series standards on industrial marketing. Industrial Marketing Management 25 (4), 305-310.

Fortune, 2009. Fortune 500 Top Industries: Most Profitable. In CNN Money's online listing retrieved from http://money.cnn.com/magazines/fortune/fortune500/2009/performers/industries/profits/assets.html. Retrieved on 01/30/2013.

Hendricks, K.B., Singhal, V.R., 2000. Firm characteristics, total quality management, and financial performance. Journal of Operations Management 19 (3), 1-17.

Hendricks, K.B., Singhal, V.R., 2008. The effect of product introduction delays on operating performance. Management Science 54 (5), 878-892.

Hill, T., 1993. Manufacturing Strategy: Text and Cases. Macmillan Press, London.

ISO, 2011. The ISO survey of certifications–2011, available at: http://www.iso.org/iso/iso-survey.

Ketokivi, M., Schroeder, R., 2004. Strategic, structural contingency and institutional explanations in the adoption of innovative manufacturing practices. Journal of Operations Management 22 (1), 63-89.

Levine, D.I., Toffel, M.W., 2010. Quality management and job quality: How the ISO 9001 standard for quality management systems affects employees and employers. Management Science 56 (6), 978-996.

McGuire, S.J., Dilts, D.M., 2008. The financial impact of standard stringency: An event study of successive generations of the ISO 9000 standard. International Journal of Production Economics 113 (1), 3-22.

Melville, N., Gurbaxani, V., Kraemer, K., 2007. The productivity impact of information technology across competitive regimes: The role of industry concentration and dynamism. Decision Support Systems 43 (1), 228-242.

Morris, P.W., 2006. ISO 9000 and financial performance in the electronics industry. The Journal of American Academy of Business 8 (2), 227-234.

Naveh, E., Marcus, A., 2005. Achieving competitive advantage through implementing a replicable management standard: Installing and using ISO 9000. Journal of Operations Management 24 (1), 1-26.

Park, A., Yang, D., Shi, X., Jiang, Y., 2010. Exporting and firm performance: Chinese exporters and the Asian financial crisis. The Review of Economics and Statistics 92 (4), 822-842.

Rogers, K., Purdy, L., Safayeni, F., Duimering, P., 2007. A supplier development program: Rational process or institutional image construction? Journal of Operations Management 25 (2), 556-572.

Savin, N.E., White, K.J., 1977. The Durbin-Watson test for serial correlation with extreme sample sizes or many regressors. Econometrica 45 (8), 1989-1996.

Sharma, D., 2005. The association between ISO 9000 certification and financial performance. International Journal of Accounting 40 (2), 151-172.

Sila, I., 2007. Examining the effects of contextual factors on TQM and performance through the lens of organizational theories: An empirical study. Journal of Operations Management 25 (1), 83-109.

Singh, P.J., Power, D., Chuong, S.C., 2011. A resource dependence theory perspective of ISO 9000 in managing organizational environment. Journal of Operations Management 29 (1-2), 49-64.

Sousa, R., Voss, C.A., 2008. Contingency research in operations management practices. Journal of Operations Management 26 (6), 697-713.

Sroufe, R., Curkovic, S., 2008. An examination of ISO 9000:2000 and supply chain quality assurance. Journal of Operations Management 26 (4), 2008, 503-520.

Swink, M., Jacobs, B.W., 2012. Six Sigma adoption: Operating performance impacts and contextual drivers for success. Journal of Operations Management 30 (6), 437-453.

Terlaak, A., King, A.A., 2006. The effect of certification with the ISO 9000 quality management standard: A signaling approach. Journal of Behavior and Organization 60 (4), 579-602.

Wakelin, K., 2001. Productivity growth and R&D expenditure in UK manufacturing firms. Research Policy 30 (7), 1079-1090.

Zhang, D., Linderman, K., Schroeder, R.G., 2012. The moderating role of contextual factors on quality management practices. Journal of Operations Management 30 (1), 12-23.

Zobel, B., 1984. The changing quality of the world wood supply. Wood Science and Technology 18 (1), 1-17.

Table 1 Industry and yearly distribution of sample firms

Industry (2-digit SIC code)	Description	Number of Sample Firms		Year of Certification	Number of Sample Firms
20	Food and Kindred Products	3		1990	1
22	Textile Mill Products	1		1991	3
23	Apparel and Other Textile Products	1		1992	15
25	Furniture and Fixtures	6		1993	36
26	Paper and Allied Products	14		1994	54
27	Printing and Publishing	1		1995	51
28	Chemicals and Allied Products	48		1996	49
29	Petroleum and Coal Products	2		1997	40
30	Rubber and Misc. Plastics Products	9		1998	29
32	Stone, Clay, and Glass Products	5		1999	36
33	Primary Metal Industries	12		2000	30
34	Fabricated Metal Products	15		2001	18
35	Industrial Machinery and Equipment	86		2002	33
36	Electronic and Other Electric Equipment	111		2003	36
37	Transportation Equipment	28		2004	7
38	Instruments and Related Products	89			
39	Misc. Manufacturing Industries	7			
Total		**438**		**Total**	**438**

Table 2 Pearson correlation coefficients and descriptive statistics on various research variables

	Post-Certification ROA[a]	Firm Size[b]	Pre-Certification ROA	Non-ISO 9000 Certified Firms' ROA Change	Industry Size[c]	Firm Technology Intensity	Firm Labor Productivity	Firm Labor Intensity	Industry Efficiency Level	Industry Competitiveness	Industry Sales Growth	Industry ISO 9000 Adoption Level
Post-Certification ROA[a]	1											
Firm Size[b]	0.226**	1										
Pre-Certification ROA	0.521**	0.246**	1									
Non-ISO 9000 Certified Firms' ROA Change	-0.053	0.143**	-0.273**	1								
Industry Size[c]	-0.025	0.058	-0.038	0.013	1							
Firm Technology Intensity	-0.387**	-0.133**	-0.508**	-0.019	0.075	1						
Firm Labor Productivity	0.400**	0.224**	0.764**	-0.207**	0.016	-0.676**	1					
Firm Labor Intensity	-0.025	-0.441**	-0.165**	-0.024	-0.032	-0.001	-0.186**	1				
Industry Efficiency Level	-0.197**	-0.015	-0.125**	-0.097*	-0.198**	-0.124**	0.013	0.123**	1			
Industry Competitiveness	-0.181**	0.108*	-0.002	0.032	-0.279**	-0.100*	0.027	0.001	0.382**	1		
Industry Sales Growth	0.169**	0.025	0.124**	-0.047	-0.005	-0.126**	0.096*	0.009	-0.079	0.006	1	
Industry ISO 9000 Adoption Level	-0.184**	-0.232**	-0.184**	-0.001	0.370**	0.224**	-0.159**	0.044	-0.397**	-0.287**	-0.102*	1
Mean	0.045	1978	0.024	-0.035	410.102	0.120	0.018	0.017	0.096	0.056	0.094	0.396
Standard Deviation	0.152	4837	0.153	0.185	286.255	0.363	0.047	0.017	0.044	0.032	0.068	0.287
Minimum	-0.707	1.252	-0.944	-2.712	10.830	0.000	-0.320	0.000	-0.162	0.024	-0.113	0.000
Maximum	0.482	36892	0.471	0.713	1440.246	4.673	0.210	0.159	0.191	0.293	0.430	0.828

**Correlation is significant at the 0.01 level (2-tailed); *correlation is significant at the 0.05 level (2-tailed). [a] industry median adjusted; [b] in million US$; [c] in billion US$

Table 3 Estimated coefficients from HLM analyses of post-certification industry-adjusted ROA

	Base Model			Control-variable Model			Firm-level Model			Industry-level Model		
Fixed Effects												
Intercept	0.043	(4.333)	***	0.028	(1.217)		0.002	(0.086)		0.006	(0.262)	
Firm Size				0.002	(0.804)		0.007	(1.869)	**	0.008	(2.249)	***
Pre-certification ROA				0.486	(11.295)	***	0.533	(9.629)	***	0.460	(8.340)	***
Non-ISO 9000 Certified firms' ROA Change				0.071	(2.040)	**	0.029	(0.843)		0.011	(0.318)	
Industry Size				0.000	(1.070)		0.000	(1.056)		-0.000	(-0.269)	
ISO 9000 Version's Dummy				-0.066	(-2.702)	***	-0.065	(-2.720)	***	-0.097	(-4.013)	***
Single-plant Dummy				-0.032	(-1.879)	**	-0.023	(-1.420)	*	-0.029	(-1.790)	**
Firm level (level 1)												
Firm Technology Intensity (H1)							-0.112	(-4.506)	***	-0.114	(-4.696)	***
Firm Labor Productivity (H2)							-0.960	(-4.085)	***	-0.810	(-3.518)	***
Firm Labor Intensity (H3)							0.999	(2.483)	***	1.064	(2.703)	***
Industry level (level 2)												
Industry Efficiency Level (H4)										-0.713	(-4.103)	***
Industry Competitiveness (Herfindahl index)(H5)										-0.652	(-3.071)	***
Industry Sales Growth (H6)										0.246	(2.806)	***
Industry ISO 9000 Adoption Level (H7)										-0.045	(-1.706)	**
	Variance Component			Variance Component			Variance Component			Variance Component		
Intercept	0.004			0.001			0.001			0.000		
Sigma- Square	0.018			0.015			0.014			0.013		
Firm-level observations	438			438			438			438		
Industry-level observations	114			114			114			114		
-2 log likelihood (deviance)	-437.16			-508.88			-534.72			-569.89		
Change in chi-square				-71.72		***	-25.84		***	-34.87		***
Change in *R*-square				29.45%			7.07%			11.15%		

Note: Significance levels (one-tailed tests) of independent variables: $p < 0.1$*; $p < 0.05$**; $p < 0.01$*** ; t-statistics in parentheses