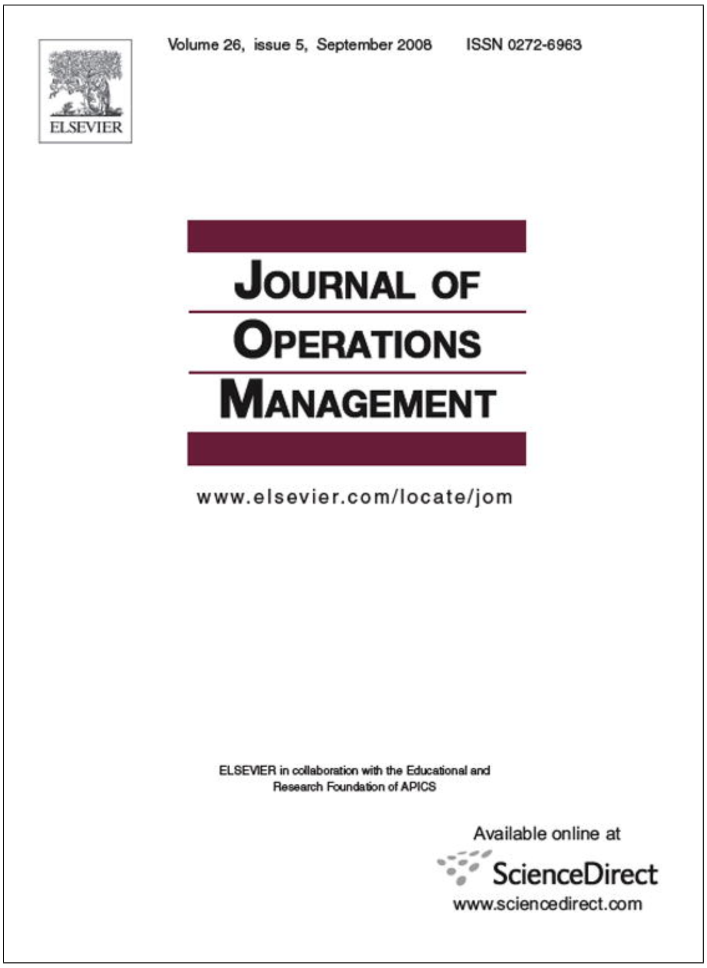
Volume 26, issue 5, September 2008
ISSN 0272-6963
ELSEVIER
JOURNAL OF OPERATIONS MANAGEMENT
www.elsevier.com/locate/jom
ELSEVIER in collaboration with the Educational and Research Foundation of APICS
Available online at
ScienceDirect
www.sciencedirect.com

Available online at www.sciencedirect.com
ScienceDirect
Journal of Operations Management 26 (2008) 611–629
Journal of Operations Management
www.elsevier.com/locate/jom

ISO 9000 practices and financial performance: A technology coherence perspective

Mary J. Benner [a,1], Francisco M. Veloso [b,c,*]

[a] *Management Department, The Wharton School, University of Pennsylvania, 2010 Steinberg Hall-Dietrich Hall, Philadelphia, PA 19104-6370, United States*
[b] *Engineering and Public Policy, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States*
[c] *Faculdade de Ciencias Economicas e Empresariais, Universidade Catolica Portuguesa, 1649-023 Lisbon, Portugal*

Received 25 July 2006; received in revised form 18 October 2007; accepted 22 October 2007
Available online 20 February 2008

Abstract

Attention to processes has increased, as thousands of organizations have adopted process-focused programs such as TQM and ISO 9000. Proponents of such programs stress the promise of improved efficiency and profitability. But research has not consistently borne out these prospects. Moreover, the expectation of universal benefits is not consistent with research highlighting the important role of firm-specific capabilities in sustaining competitive advantage. In this paper, we use longitudinal panel data on ISO 9000 practices for firms in the auto supplier industry to study two new issues related to the adoption of process management practices. First, we find that, as the majority of firms within an industry adopt ISO 9000, late adopters no longer gain financial benefits from these practices. Second, we explore how firms' technological coherence moderates the performance advantages of ISO 9000 practices. We find that firms that have a very narrow or very broad technological focus have fewer opportunities for complementary interactions that arise from process management practices and thus benefit less than those with limited breadth in technologically related activities.

Keywords: Operations strategy; Technology management; Quality management; Empirical research methods

1. Introduction

A central question in strategy is: How do firms achieve sustainable competitive advantage? Research is often aimed at assessing whether particular organizational practices can deliver sustainable advantages, especially given that other firms can also adopt similar practices. Practices aimed at improving operational effectiveness may benefit adopting firms for a time, but if a firm's competitors can all adopt the same practice, the benefits will be competed away (Porter, 1996). Firms are then frustrated in their efforts to translate performance improvements into relative financial performance advantage. If a generic ''best practice'' can be copied and equally benefit all potential adopters, it cannot confer lasting benefits (e.g. Lieberman and Montgomery, 1988; Porter and Siggelkow, 2004; Levinthal, 2000). However, if an organizational practice is firm-specific, valuable, and difficult to imitate, it may lead to sustainable competitive advantage (cf. Barney, 1991; Peteraf, 1993).

* Corresponding author at: Engineering and Public Policy, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States. Tel.: +1 412 268 4640.
E-mail addresses: benner@wharton.upenn.edu (M.J. Benner), fveloso@cmu.edu (F.M. Veloso).
[1] Tel.: +1 215 746 5719.

0272-6963/$ – see front matter
doi:10.1016/j.jom.2007.10.005

Research in strategy, in particular, in the Resource-Based View, has increasingly focused on the central role of firm-specific, unique, and inimitable capabilities in creating competitive advantage (e.g. Peteraf, 1993; Barney, 1991). Organizational routines or processes have emerged as critical building blocks in these difficult-to-imitate capabilities (e.g. Teece et al., 1997; Dosi et al., 2000; Eisenhardt and Martin, 2000). At the same time, a focus on organizational routines and processes has increased in managerial practice. Thousands of firms have embraced the process-focused practices that underlie a progression of popular quality improvement programs, including Total Quality Management (TQM), Business Process Reengineering, the Malcolm Baldrige Award Criteria, and more recently, the ISO 9000 certification program and Six Sigma (e.g. Staw and Epstein, 2000; Garvin, 1991, 1995; Cole, 1998; ISO, 2007). While these programs differ in scope and approach, they share a core focus on systematic attention to operational processes in organizations, and involve mapping, improving, and adhering to systems of repeatable processes (Hackman and Wageman, 1995; Benner and Tushman, 2002).

Proponents of process management practices cite expectations of improved quality and efficiency, leading to increased revenue, reduced costs, and ultimately, higher profits (e.g. Winter, 1994; Garvin, 1995; Hammer and Champy, 1993; Harry and Schroeder, 2000), and these expectations are also reflected in most empirical research on the performance implications of process management practices (e.g. Easton and Jarrell, 1998; Corbett et al., 2005; Ittner and Larcker, 1997). However, despite the widespread assumption that organizations will benefit from process management, the findings from research have been equivocal. While some research demonstrates the anticipated financial advantages (e.g. Easton and Jarrell, 1998; Corbett et al., 2005; Hendricks and Singhal, 1997), other research has not found better business performance associated with the actual process-focused techniques (e.g. Powell, 1995; Staw and Epstein, 2000; Terziovski et al., 1997; Samson and Terziovski, 1999). Still other research has found that the effects dissipate over time (Wayhan et al., 2002; Casadesus and Karapetrovic, 2005).

One explanation for these contrasting results, which has not been considered in previous research, is that the financial performance advantages that may accrue to early adopters can disappear for the later ones, as more firms in an industry adopt and achieve similar generic improvements in efficiency and quality. Indeed, process management programs often have been viewed as generic improvement practices that are easily adopted by all firms (e.g. Hammer and Champy, 1993; Harry and Schroeder, 2000; Pande et al., 2000). In that case, even as firms improve their own operational efficiency, it will be increasingly difficult to translate these improvements into sustainable relative financial performance advantages over time as firms within an industry increasingly adopt identical practices and achieve similar reductions in cost, improvements in quality, or access to new customers (cf. Porter, 1996; Lieberman and Montgomery, 1988).

However, generic organizational improvement practices may confer lasting benefits if they interact with firm-specific routines and give rise to unique capabilities that are difficult to imitate. Since process management implementation is aimed directly at organization-specific processes and capabilities, and in particular, at streamlining processes and the handoffs between processes across an organization, process management practices affect the potential for firms' capabilities to lead to competitive advantage. Specifically, by tightening the linkages between unique organizational processes, process management practices can increase the "fit" or complementarities among organizational activities (cf. Siggelkow, 2002). Thus, the potential for process management to lead to competitive advantage will differ across firms, depending on firm-specific characteristics. In line with existing perspectives in manufacturing strategy (White, 1996; Miller and Roth, 1994), some research looking at process management has also begun to recognize that the impact of process management practices may depend on firm characteristics (e.g. Benson et al., 1991; Das et al., 2000; Sousa, 2003; Ettlie, 1997; see also Sousa and Voss, 2002 for a recent review of research on quality improvement). However, research has not provided consistent analyses of how the interaction with a firm's technological coherence, i.e. the narrowness or breadth of a firm's technologies, affects the financial performance benefits of process management practices.

In this paper, we go beyond prior research, drawing from strategy and organization theory literature to better understand how competitive advantage arises for firms adopting process management practices. We study the ISO 9000 quality certification program, a set of process-focused practices which became increasingly popular and were widely adopted by organizations throughout the 1990s. We explore two questions that have not been addressed in previous studies. First, we ask what happens to the financial performance benefits of firms following the adoption of the process-focused practices associated with ISO 9000 as the majority of competitors in an industry undertake identical practices. We argue that as ISO 9000 is widely adopted in an industry, efficiency improvements are less likely to translate directly into higher profits, as generic process management practices can be imitated (cf. Barney, 1991; Peteraf, 1993), and will not confer lasting advantage (e.g. Lieberman and Montgomery, 1988; Porter, 1996). Second, we consider how the financial performance advantages of ISO 9000 are influenced by firm-specific technological characteristics. We follow prior work that explores relatedness or coherence in a firm's technological capabilities (e.g. Patel and Pavitt, 2000; Silverman, 1999; Teece et al., 1994; Wolter et al., 2003), and analyze how technological coherence moderates the effects of ISO 9000 practices on performance. This approach also reflects research in strategy that suggests firms have opportunities to create greater advantage from related businesses (e.g. Rumelt, 1982; Singh and Montgomery, 1987). The process management practices associated with programs like ISO 9000 may be one vehicle for creating linkages and synergies across related activities.

We study these ideas using a unique, comprehensive, longitudinal dataset for firms in the auto supply industry. Studying these questions within one industry where process management adoption has become ubiquitous allows us to assess the changes in relative performance advantages over time, while better controlling for industry effects that also influence firm performance. We assess the moderating role of technological coherence with a firm-specific measure developed from a comprehensive assessment of the technologies used by each auto supply firm.

We estimate models of the impact of process management on firm performance using panel data with firm fixed effects and year controls. This longitudinal approach statistically controls for firm-specific unobserved factors correlated with both performance and adopting a process management program like ISO 9000, which could lead to erroneous inference and might confound our findings. For example, firms that adopt may have systematically different performance levels for reasons unrelated to ISO 9000 adoption. Identifying our estimate from the change in performance (more specifically, from the within-firm variation) avoids attributing differences in levels of performance that are independent of adoption to the adoption itself.

The paper proceeds as follows. In Section 2, we develop our hypotheses about process management's effects, and specifically, the effects of practices underlying the ISO 9000 certification program, on firms' financial performance. In Section 3, we discuss our measures and models. Section 4 presents the results of our empirical tests. In support of our hypotheses, we find that the financial performance benefits of ISO 9000 practices disappear as the majority of competitors in an industry adopt similar practices, and further, that the performance benefits of ISO 9000 process management practices are indeed moderated by firm-specific technological coherence. This relationship exhibits an inverted U-shape: very narrowly or very broadly focused firms have fewer opportunities to take advantage of the potential for improved internal fit or complementary interactions among related firm activities, while firms with moderate breadth in technologically related activities appear to benefit the most from practices focused on operating processes. We conclude with a discussion of the implications of this work for research and practice, and possible extensions.

2. Literature review and research development

A progression of quality improvement programs over the past few decades such as TQM, the Malcolm Baldrige Criteria, ISO 9000, and Six Sigma share a focus on improving and adhering to repeatable organizational processes as the mechanism for improving quality, efficiency, and financial performance. These programs begin with mapping or documenting an organization's operating processes (e.g. Dean and Bowen, 1994; Hackman and Wageman, 1995; Hammer and Champy, 1993; ISO, 2007). This is typically followed by concerted efforts to improve and streamline processes by eliminating wasted steps and coordinating the handoffs between processes across the organization (e.g. Hackman and Wageman, 1995; Anderson et al., 1994). The final stage in process management programs is a focus on adhering to systems of standard processes that result from these streamlining efforts (e.g. Harry and Schroeder, 2000; Heaphy and Gruska, 1995; Mukherjee et al., 1998; ISO, 2007).

The ISO 9000 quality certification program, the focus of this paper, has gained widespread attention in both research and practice over the past two decades (e.g. Corbett, 2002; Guler et al., 2002; Harrington and Mathers, 1997). Like other process management programs, ISO 9000 focuses on improvement in an organization's operating processes as the means to improve quality and efficiency. Organizations receive ISO 9000 certifications after demonstrating that they have mapped operating processes associated with the quality of their products, such as manufacturing, new product development, and customer service, and that they conform to these repeatable, documented processes. In addition to its diffusion, ISO 9000 Quality Certification is also an interesting practice to analyze because it reduces the challenge of assessing whether firms are really undertaking process improvement practices (cf. Powell, 1995; Easton and Jarrell, 1998; Zbaracki, 1998; Westphal et al., 1997). ISO 9000 certification requires a third-party registrar, such as Underwriters' Laboratories (UL), to verify that an organization is undertaking practices focused on documenting and adhering to its operating processes.

2.1. ISO 9000 and firm performance

As ISO 9000 has gained popularity in practice, researchers have sought to understand its effects on organizations. Often such research has aimed at assessing the financial performance benefits for firms from ISO 9000 adoption, and a large body of literature that studies the effects of ISO 9000 shares the general assumption that ISO 9000 adoption will improve an organization's financial performance (e.g. Corbett et al., 2005; Sharma, 2005; Simmons and White, 1999; Naveh and Marcus, 2005; Heras et al., 2002b). Prior research highlights two possible sources of performance improvements from ISO 9000. First, performance improvement is expected to arise from improved operational efficiencies that translate directly into cost reductions. These efficiency improvements stem in part from the initial efforts to document and rationalize processes, resulting in less wasted effort and duplication. Researchers and proponents of ISO 9000 argue that additional efficiency improvements arise as organizations consistently conform to the resulting documented, standardized procedures, and these "in control" processes further improve yields of defect-free products, translating into reduced waste and costs (Anderson et al., 1999; Corbett et al., 2005; Terziovski et al., 2003). These arguments also echo prior research in organizational learning theory that suggest that repetition of standard routines in organizations gives rise to incremental benefits of learning-by-doing (cf. Levitt and March, 1988; Levinthal and March, 1993; Benner and Tushman, 2003).

A second expected source of performance improvement from adopting the ISO 9000 program arises from increases in revenue as ISO 9000-certified firms are able to access new markets or customers (e.g. Corbett et al., 2005; Terlaak and King, 2006). Terlaak and King (2006) studied ISO 9000 certifications as signals of quality and found that suppliers that were ISO 9000 certified grew faster than non-certified organizations.

Existing research further suggests that the increased efficiency and sales from ISO 9000 will translate directly into improved profitability through cost reductions and revenue increases (Corbett et al., 2005; Terziovski et al., 2002). In line with these predictions, some research has indeed found evidence of the expected improvements in financial performance from ISO 9000 (e.g. Corbett et al., 2005; Terlaak and King, 2006; Heras et al., 2002a; Haversjo, 2000). Relatedly, other research has found a positive stock market reaction to ISO 9000 certification, reflecting an assumption that expectations of future financial performance improvement from ISO 9000 will affect investors' behaviors (e.g. Nicolau and Sellers, 2002). Thus, following the predictions and evidence from prior research on the ISO 9000 program, our first hypothesis is:

Hypothesis 1a. Adoption of ISO 9000 practices by a firm will result in improved financial performance.

However, the results of other research on ISO 9000 have not consistently supported the expectations of benefits from ISO 9000 certification. Some researchers have found no financial performance benefits associated with ISO 9000 certification (Morris, 2006; Terziovski et al., 1997; Heras et al., 2002b; Lima et al., 2000; Dick, 2000). Still other research has found that although improvements in operational efficiency resulted from ISO 9000 adoption, these benefits did not translate into financial performance improvements (Sharma, 2005; Naveh and Marcus, 2005) or the benefits faded over time (Wayhan et al., 2002; Casadesus and Karapetrovic, 2005). These findings mirror the conflicting results of research on process management programs more broadly, reflected in a large body of research on TQM. For example, while some existing research has shown financial performance advantages (Easton and Jarrell, 1998; Wruck and Jensen, 1994; Ittner and Larcker, 1997; Hendricks and Singhal, 1997) or positive effects on a firm's stock price (Hendricks and Singhal, 1996, 2001) resulting from TQM, other studies have not found performance improvements associated with process-focused approaches (e.g. Powell, 1995; Samson and Terziovski, 1999; Staw and Epstein, 2000). Sterman et al. (1997) found that the improved yields and reduced waste resulting from TQM did not translate into better financial performance. In a recent review, Sousa and Voss (2002) conclude that the "impact of Quality Management practices on business performance is weak(er) and not always significant." In still other research that has found financial benefits of TQM adoption, the results are not due to the implementation of process-focused techniques, but to other elements of the larger package of TQM practices, such as executive commitment or employee empowerment (e.g. Samson and Terziovski, 1999; Powell, 1995). This is surprising as it is specifically the attention to improvement and conformance to processes that is expected to lead to performance improvements.

The conflicting results of prior work leave open the question of how process management practices such as ISO 9000 affect organizations. Prior research in strategy suggests reasons why advantages from ISO 9000 certification may be hard to obtain or fleeting for firms that initially achieve them. To confer competitive advantage on a firm, practices must be valuable, as prior research suggests is the case with ISO 9000, but also inimitable (cf. Barney, 1991; Peteraf, 1993). The generic adoption of ISO 9000 practices, while potentially valuable for reducing inefficiencies or gaining new customers, is likely not inimitable. For example, the increased sales that may initially arise from the quality signal associated with an ISO 9000 certification (cf. Terlaak and King, 2006) are likely to fade as more of an organization's competitors are also certified and therefore offer an equivalent signal of quality and can compete for the same new customers. Similarly, the improvements in efficiency and potential cost reductions as firms get better at their unique sets of activities through repeatable processes are likely to dissipate as a greater number of firms achieve similar generic efficiency improvements in their own routines. Thus, the main benefits of ISO 9000 cited in prior research can be imitated by any organizations that undertake the ISO 9000 practices, follow repeatable processes, and are granted an ISO 9000 certification (e.g. Porter, 1996; Powell, 1995). We anticipate that as the majority of firms in an industry adopt, it will be increasingly difficult to translate improvements associated with ISO 9000 practices into sustainable relative financial performance advantages, as most other competitors are achieving the same improvements (e.g. Lieberman and Montgomery, 1988; Porter, 1996). Thus, although adoption of ISO 9000 may be necessary for successful participation in the industry, over time, it may not be possible to achieve relative financial advantages over competitors simply by adopting ISO 9000 practices. This is an important possibility that has not been explored in prior empirical work on ISO 9000 or process management practices more broadly.

Thus, we modify the predictions in Hypothesis 1a with the following:

Hypothesis 1b. Adoption of ISO 9000 practices by firms within an industry will be associated with performance benefits for early adopters, but lower performance benefits for later adopters.

Some research, following institutional theory (cf. DiMaggio and Powell, 1983; Meyer and Rowan, 1977; Zucker, 1986; Zbaracki, 1998), has also suggested that the benefits of process management will differ for early and later adopters (Westphal et al., 1997). In this view, early adopters gain performance advantages from process management programs such as TQM, while later adopters gain legitimacy advantages but not actual improvements in technical efficiency. In these studies, however, the differences arise because of differences in the actual practices undertaken by early and late adopters; later adopters fail to utilize the actual techniques that would generate efficiency benefits (Westphal et al., 1997). This echoes work in institutional theory more generally suggesting that the lack of performance benefits from administrative innovations like process management stem from a disconnect between an organization's claims about adoption, that is, the rhetoric about the use of such practices and the actual implementation (cf. Zbaracki, 1998; Meyer and Rowan, 1977).

Since receiving an ISO 9000 certification involves periodic audits by third-party registrars to ensure that organizations are documenting and conforming to processes, there is little chance for an organization to be certified without undertaking the actual practices. Early and later adopters in our study are likely to be undertaking similar activities to achieve and maintain ISO 9000 certification. As a result, our study departs from the institutional theory arguments as we can assess the performance differences that arise earlier and later from the adoption of identical practices. Thus, although the general idea that performance benefits of process management can be greater for early adopters is not new, we are able to study the idea that ISO 9000 benefits can be imitated and the performance advantages lessened for later adopters.

2.2. *The role of technological coherence*

But are there conditions under which firms can gain and sustain performance benefits from practices focused on improving processes? Prior research suggests that sustainable competitive advantage arises as underlying firm activities are coordinated to create unique firm-specific interactions or complementarities that are difficult to imitate (Porter and Siggelkow, 2004).

Tighter coordination of organizational activities occurs as stable routines or standard processes are repeated (cf. Hannan and Freeman, 1984). The ISO 9000 program is likely to further these organizational tendencies as it involves techniques specifically aimed at adhering to standard routines, resulting in tightened coordination between interdependent processes in an organization. For example, an organization focused on improving the efficiency and quality of its manufacturing process is likely to also focus attention on the handoffs or linkages between manufacturing and the product development process upstream. Efforts to develop products that can be more easily manufactured results not only in further improvements in manufacturing, but also creates tighter interactions between product development and manufacturing processes. Similarly, process management spurs tighter linkages between other upstream and downstream activities across an organization (e.g. Dean and Bowen, 1994). As an organization carries out activities through conformance to standardized processes, and further, improves processes by tightening the coordination between processes, it is likely to achieve greater ‘‘fit’’ between activities (e.g. Siggelkow, 2002). The resulting configuration of interconnected capabilities is increasingly firm-specific and difficult to imitate. Moreover, because these underlying sets of routines and capabilities differ across organizations, the performance advantages that arise from the interaction of process management practices with underlying routines are also likely to differ.

In this research, we consider the role of technological breadth or coherence. In doing so, we follow a growing body of research in strategy that assesses the extent of relatedness in firms' capabilities and resources with measures of technological breadth (Silverman, 1999; Argyres and Silverman, 2004; Miller, 2004). Researchers have argued that technological breadth provides a finer grained measure of firms' activities and resources than market based measures of relatedness drawn from a firm's participation by SIC codes (e.g. Jaffe, 1989; Silverman, 1999). In existing research, the technology categories listed on a firm's patents are frequently used as an indicator of its technological breadth. However, the technology classes in which a firm patents (invents) can understate the full range of its capabilities (Silverman, 1999). Thus, as explained in detail in the methods section, our measure of the breadth of technological activities has been carefully constructed by assessing the range of firms' actual activities in a particular industry, automobile suppliers in our case.

Prior work suggests that the extent of coherence or relatedness in a firm's underlying technologies offers differential opportunities for creating firm-specific interactions and complementarities that can lead to competitive advantage (e.g. Hill and Hoskisson, 1987). Evidence from the diversification literature shows that related diversification can result in higher performance than unrelated (e.g. Rumelt, 1982; Singh and Montgomery, 1987; Teece et al., 1994). Related diversifiers are expected to be better able to exploit economies of scope, and thus create strategic assets more efficiently than competitors. Because of relatedness in their technological activities, they can more efficiently tap into their core capabilities and generate synergies between business units or segments and thus exhibit a better performance vis-a-vis narrowly focused units and unrelated diversifiers. In our setting, for example, a firm that does die casting would more easily gain more from diversifying to investment casting rather than plastic injection molding (see next section for a complete description of the measure used to implement the concept of technology coherence). The benefits of relatedness arise, in part, because of the greater potential for unique combinations of resources and capabilities as firms coordinate related activities more closely (e.g. Hill and Hoskisson, 1987).

Since process-focused practices provide a mechanism for linking organizational activities, their benefits are likely to be greater in firms that have some opportunities to gain synergies from linking related activities. Thus, we hypothesize that coherence or breadth in a firm's technologies will moderate the performance effects of ISO 9000 practices. A narrowly focused, technologically coherent firm is unlikely to have many opportunities for unrealized synergies across activities that the application of process management techniques can uncover. Such firms have less to gain from activities that increase coordination and the potential for complementarities between activities. The benefits for firms with high technological coherence are thus more likely to arise from generic efficiency improvements rather than from inimitable interactions in activities, and as a result, may also be competed away more easily through imitation (e.g. Porter, 1996; Lieberman and Montgomery, 1988). But as a firm increases the breadth of its technologies beyond a narrow, coherent focus, its opportunities to realize synergies from related activities also increase. Process management practices can help create firm-specific interdependencies among related activities that are not easily imitated.

We expect that the benefits of the process-focused practices underlying ISO 9000 will increase with increasing breadth in an organization's technologies as firms move from very narrow, coherent technologies to greater breadth in related technological activities. But this effect will be greatest for firms with related technologies that offer opportunities for synergies and complementary interactions. As firms move toward very high technological breadth or unrelated activities, there is less potential for the complementary and hard-to-imitate interactions that arise from tighter coordination of related activities, and it may be difficult for these firms to implement process management practices across disparate activities, hindering their ability to reap any value from the potential for better coordination and tighter linkages that arise from standardizing and integrating processes (e.g. Repenning and Sterman, 2002). As a result the benefits of ISO 9000 activities for performance will be lessened for very low and very high levels of technological breadth. Thus, we hypothesize:

Hypothesis 2. Technological coherence will moderate the effect of ISO 9000 practices on performance. The performance benefits of ISO 9000 practices will increase with greater technological breadth, and will be highest for firms with moderate level of breadth in related technological activities. But for firms with high technological breadth or unrelatedness, the performance benefits of ISO 9000 practices will be lower (i.e. the moderating effect of technological breadth on the performance benefits of ISO 9000 practices will shift from positive to negative).

3. Data and measures

3.1. Data construction

We test our hypotheses on a sample of firms from a single industry, the automotive supplier industry in the U.S. during the 1990s. We chose this industry and time frame for several reasons. First, process management adoption has been ubiquitous in this industry, which allows us to assess how performance benefits of process management practices are affected as firms within an industry increasingly adopt them. Second, using data from a single industry also helps us better control for heterogeneity and avoid other complications inherent in inter-industry analysis (Montgomery and Wernerfelt, 1988). Third, we are able to use a unique dataset with detailed, comparable information on technological characteristics for firms in this industry. Finally, we study these questions during a time period where ISO 9000 adoption increasingly became a requirement for participation in the sector; while at the end of the eighties none of the firms had adopted ISO 9000, by the end of our observations, three quarters of the total had adopted. In addition, reporting requirements for financial disclosures of business segment information changed in 1998; we therefore chose the 10-year period from 1988 to 1997 to exclude the effect of these reporting changes. The time period covers approximately one full economic cycle of the automotive industry.

Auto parts firms are defined as firms primarily engaged in manufacturing finished and semi-finished automotive components. This definition excludes suppliers of raw materials, tool manufacturers, suppliers of instrumentation and computer services, testing services, software developers, pure R&D companies, pure manufacturers of components for trucks and other transportation equipment, and pure automotive aftermarket firms. To include as many firms as possible in the analysis, a broad list containing over 650 firm names was compiled from multiple sources. These included firms in COMPUSTAT with at least one business segment representing SIC code 3714 (Motor Vehicle Parts & Accessories) and/or business segments having an automotive manufacturer as primary business segment customer; firms listed in the Market Data Book of Automotive News, and firms listed in the Automotive Engineering International Annual Product Sourcing Guide, North America. This list was then narrowed down to meet the criteria of the industry definition. Data on firm technology was accessed from company annual reports (10-K) filed with the Securities Exchange Commission (SEC), financial data was from COMPUSTAT, and data on ISO 9000 certifications was obtained from McGraw Hill's database of registered companies.

Our data set encompasses only U.S. registered, public companies. As our interest is specifically in the firms participating in the sector, a firm was included in the data if it had at least one business segment whose sales to the automobile industry represented a minimum of 50% of its of total sales. The baseline data set included 89 firms in the 10-year period covering approximately US$ 120 billion of annual sales. In addition, to assure consistency in our estimations, we also eliminated from this baseline sample firms for which we only had partial information on performance metrics.[2] Finally, a few outlier observations were excluded from the sample. The final dataset includes a panel of 75 firms.

[2] Allowing for the sample to include observations where performance data are available for some of the metrics but not others does not change the overall results.

We use data from the ISO 9000 certification program as the relevant proxy for a firm's commitment to process management practices. While ISO 9000 differs in approach from other process management programs such as TQM and Six Sigma, this measure has several advantages. A challenge with using TQM adoption to represent process management practices is heterogeneity in the actual practices that firms adopt, and the difficulty of assessing whether firms actually undertake any process-focused practices (e.g. Easton and Jarrell, 1998; Zbaracki, 1998). In contrast, ISO 9000 certification requires that firms document and demonstrate adherence to their processes in periodic audits conducted by third-party registrars (such as UL), which increases the likelihood that firms are engaging in systematic attention to underlying processes. In addition, the registrars provide the certification data, which helps overcome the subjectivity of firm self-reports in surveys of quality program adoption (cf. Easton and Jarrell, 1998). Moreover, the institutional mandate for ISO 9000 adoption, particularly in the auto industry, has been greater than for other quality programs during this period (e.g. Guler et al., 2002; Terziovski et al., 2003). These pressures for ISO 9000 make the adoption ''decision'' less endogenous than in the cases of TQM or Six Sigma. Because these other programs have been much more voluntary in nature, it is more likely to have the firms that can benefit from them self-selecting into adoption, potentially biasing the estimation of the impact of adoption on performance (e.g. Easton and Jarrell, 1998; Corbett et al., 2005).

We used ISO 9000 certification data provided from McGraw-Hill's ISO 9000 Registered Company Database on a CD each quarter. We included a certification in our data if we could verify from location and company information that it was attributable to a firm in our dataset. We used the date listed on the certification, so the first date of adoption of ISO 9000 was represented by the first ISO 9000 certification for that firm. We also cross-checked the data with earlier versions to ensure we had initial dates of each certification rather than renewal dates.

Finally, it is important to recognize that, while financial performance is measured at the corporate level, firms can have multiple ISO certifications, even within the same location. Ideally, one would measure the financial performance of the particular part of a company associated with a given ISO 9000 certification. But, unfortunately, such detailed information does not exist. As a result, we follow an established practice (see Docking and Dowen, 1999; Simmons and White, 1999; Corbett et al., 2005) and focus on a firm's first certification. For small firms with a unique location, this is not an issue because there is no difference between site certifications and firm performance. But such a difference exists for large firms with many sites. However, this disconnect would work against finding any effects in our analysis. If a firm has multiple sites being certified separately, the certification of only the first location is likely to have a smaller effect on the financial performance of the firm. Thus, the effects of certification must be strong in order to be captured by our estimation. This makes our results potentially conservative.

3.2. Measures

3.2.1. ISO adoption

Our primary measure of ISO 9000 adoption is a binary measure for each firm that equals zero until the year the firm receives its first ISO 9000 certification, and equals one thereafter. For example, if a firm became ISO 9000 certified in 1993, its ISO 9000 adoption variable would be zero from 1988 until 1992 and one from 1993 to 1997. In addition, we also created an individual firm time trend since adoption. This helps capture the idea that efficiency or legitimacy benefits unfold over time as the organization adheres to documented processes and as the potential new customers become aware of the certification. The variable is zero until first certification, then takes successive values of 1, 2, 3, etc., for subsequent years. For the firm first adopting in 1993, this variable will be zero until 1992, 1 in 1993, 2 in 1994, 3 in 1995, etc.[3] The notion that benefits may accrue over time is implicitly suggested in the estimations of Corbett et al. (2005). Although their paper does not address this issue, the empirical results do suggest an increase in performance in the years after adoption.

3.2.2. Firm performance

We measure financial performance at the firm level. Consistent with prior research, we rely on multiple measures of performance to attain robustness of results. We use two accounting measures, return on assets (ROA) and return on sales (ROS), as well as a stock

[3] We also considered an alternative specification ending the individual trend line 3 or 4 years after adoption. The results were similar. Yet another alternative would be to have both an individual trend and an adoption dummy, enabling two degrees of freedom on the post-adoption line. We also considered this, but the results, whenever significant, were no different from having just the linear trend. So we decided to use the simpler model.

market based measure, Tobin's q (the ratio between a firm's stock market value (shares outstanding × share price) and the replacement value of its assets).

3.2.3. Technology coherence

The few studies that have analyzed firm technology coherence have used patent data (see Silverman, 1999; Breschi et al., 2003; Gambardella and Torrisi, 1998). While this may be appropriate in high tech industries where patents are a critical mechanism of technology appropriation, it is not feasible in the automotive industry, where patents are only of minor importance as a measure of technology resources and capabilities. Thus, we created a measure of coherence in the portfolio of technologies of a firm through a detailed analysis of the firm's technology footprint, using a methodology developed by Steinemann (2000). First, we used a 3-level hierarchical classification scheme for technologies used in auto component manufacturing. We consider technologies within a given category to be more related to each other than to technologies in other groups at the same level. We defined relatedness, or group membership, on the basis of similarities in materials, equipment and manufacturing methods. Technical and engineering literature on automotive components served as a guideline for establishing the classification scheme (cf. Steinemann, 2000). The classifications were also validated by experts in the automotive field.

The final hierarchy has nine major technology groups. These include Assembly, Metals processing, Plastics processing, Surface treatment, Glass processing, Ceramics, Textiles processing, Chemicals processing and Electronics manufacturing. In turn, each of these groups has several subgroups. For example, Metals processing has 8 subgroups, which include, among others, Forming and Casting technologies. Altogether, there are 23 of these subgroups. The logic behind the hierarchical classification is that each of these subgroups is designed to include a set of related individual technologies. Casting, for example, part of the metal processing group, has five different individual related technologies, including die, investment casting and three others. Thus, investment and die casting are considered related to each other, but unrelated to technologies in any other of the 22 subgroups, either within the metals processing group, or in any of the other 8 major technology groups.

Second, we use this classification scheme to categorize technologies for every auto business segment of all firms present in our sample. We classified firm technologies through a detailed search of firm annual reports and SEC 10-K reports. Whenever a firm reported the presence of a given technology, we labeled its presence in one of the subgroup levels of the hierarchy. For example, if a firm uses metal stamping, compression molding, injection molding and manual assembly to manufacture the components it sells, it will have a total of four technologies, two of them in the same subgroup—Plastics Molding, and the other two in different subgroups. The resulting dataset allows us to assess which technologies at the subgroup level exist in a business segment of a given firm (more detail on the overall classification process is available in Steinemann, 2000, or from the authors upon request).

We then use a Herfindahl Concentration Index based on Berry (1975) to construct a measure of technological coherence (the inverse of diversification) for the automotive business segments of every firm. We do this by calculating $\mathrm{HCI} = \sum_i S_i^2$ for each firm in a given year, where each S_i is the share of technological competencies at the subgroup level (e.g. Casting or Molding). For example, a firm with five technologies in total, three in metal Casting and two in plastics Forming would have a coherence level of $\mathrm{COH} = [(3/5)^2 + (2/5)^2] = 0.36 + 0.16 = 0.52$[4]. The resulting variable can vary from one, if the technological competencies are all in one of the subgroups, to close to zero if the competences are distributed across all the groups (a firm with one competence in each of the 23 groups would have coherence of 1/23). Our hypothesis is that firms adopting ISO 9000 that have technology coherence levels, as measured by the HCI, that are either very high (for example, the firm does only injection molding, and the HCI measure would equal one) or very low (for example, the firm has one technology in each of the 23-level-three groups) will benefit less than those in the middle range.

3.2.4. Control measures

We included firm size measured through sales in log form to control both for the effect of size on ISO 9000 adoption and performance. Since high levels of investment can have an impact on both process management adoption and performance, we also included a control for capital expenditures for each

[4] Although we gathered yearly data, it became noticeable that the technology footprint of the firms was quite stable over this period. So, data on technology was collected only back to 1993. Moreover, in the cases where some variation occurred, we averaged the HCI over the relevant period. Thus, our measure is firm specific and not firm-year specific.

firm-year. But, since capital expenditures tends to track sales very closely, and since we were mostly concerned with having a large capital investment confounding the effect of the ISO adoption, we represented this control as a dummy that is 1 if the firm invests more than the average of the sector (5% of sales) in capital and zero otherwise.[5]

In addition, we created a measure of customer concentration to capture potential concentration effects on performance and ISO 9000 adoption. We calculated customer concentration as the Herfindahl concentration ratio of sales to the three largest buyers of automotive components in the United States, General Motors, Ford and (Daimler) Chrysler. If a firm has sales to only one of the three large automobile manufacturers, rather than evenly distributed among the three, it is presumably more subject to the idiosyncrasies of one customer with respect to pressures to adopt ISO 9000.

We also created measures of diversification in business segments and geography as control variables for firm-level data. Although firms are mostly focused on the automotive sector, some also have activities in other business segments, which could affect firm performance (see for example Montgomery and Wernerfelt, 1988; Chatterjee and Wernerfelt, 1991; Lang and Stulz, 1994). Geographic diversification may also affect firm performance, particularly in the auto industry (Sturgeon and Florida, 1997). We measure business segment and geographic diversification as the inverse of the Herfindahl Concentration Index described above for the case of technological coherence, but with S_i representing the share of a firm's sales in business (or geographical) segment i. For business segments we use different 2-digit codes for firms in SIC codes 3300–3999 or different 1-digit SIC codes otherwise. For geography, segments are one of the three largest world markets, North America, Asia and Europe. Diversification is just 1 minus the Index: DIV = 1 − HCI.

Finally, it is important to note that, in cross-sectional models, most of these measures are used to control for differences between firms. Since we will be looking at a panel with firm fixed effects, these controls for time-invariant (i.e. stable over time) cross-firm differences. Thus, the interpretation of the control measures relates to how within-firm, over time changes condition the dependent variable.

[5] Alternative definitions for this variable, including running the models without it, were tried and the overall results are unchanged.

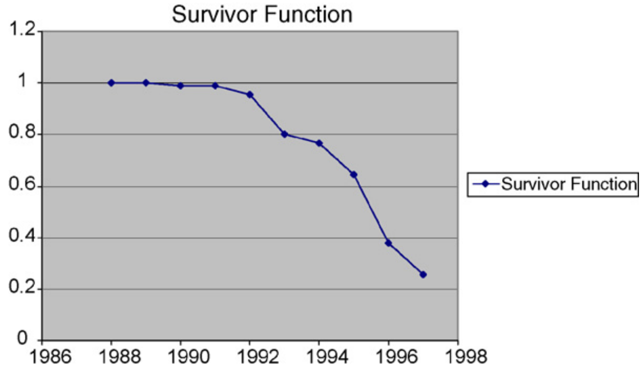

Fig. 1. Survivor function–share of non-adopters.

3.2.5. *Descriptive statistics*

Descriptive statistics for the variables are presented in Table 1. The firms in our sample had an average return on sales of 7.8% and an average return on assets of 10.1%. The average stock market value was 45% above book value. The average level of technological coherence is 0.4, but the values range from 0.1 to 1. As one might expect, Table 1 also shows that our variables are more stable within than across firms.

For the ISO adoption variable, instead of descriptive statistics, the relevant analysis is the evolution in the firm adoption pattern over the period considered in the analysis. Fig. 1 presents the survival function for the sample (i.e. those that have not adopted). As shown, the adoption pace is rather slow in the beginning, with the first adoption occurring in 1990 and only a handful of subsequent certifications happening until 1992. After that, the pace of adoption increases rapidly, with 75% certified by 1997, the last year in our analysis.

4. Empirical strategy, analysis and results

We are interested in testing the impact of process management (measured by ISO 9000 certification) on firm financial performance. How might we best measure this effect? The simplest approach would be to ask whether firms adopting process management have better performance after accounting for other correlates of performance. Ordinary least squares (OLS) does this, but a major shortcoming of this method is that the group of firms adopting may have systematically different performance from non-adopters for reasons unrelated to process management that we are unaware of. This is particularly important if some of this unobserved firm heterogeneity drives adoption (for example, high performance firms adopting early to signal their superiority) because the adoption regressor becomes correlated with the error term, potentially biasing the results. Thus, a careful empirical test of these

Table 1
Descriptive statistics and correlations for variables

Variable	Firms	Obs	Mean	Overall S.D.	Within S.D.
Return on sales (ROS)	75	457	0.078	0.043	0.024
Return on assets (ROA)	75	457	0.101	0.055	0.038
Tobin's *q*	75	457	1.452	0.631	0.361
Log of sales	75	457	2.744	0.785	0.136
Capital expenditures	75	457	0.469	0.499	0.345
Segment diversification	75	457	0.232	0.267	0.054
Geographic diversification	75	457	0.725	0.297	0.086
Customer concentration	75	457	0.143	0.183	0.073
Technological coherence	65	403	0.406	0.217	–

Variable	ROS	ROA	Tobin *q*	LgSales	Capex	SegDiv	GeoDiv	CstCC
ROS	1.00							
ROA	0.83	1.00						
Tobins *q*	0.63	0.59	1.00					
Lg of Sales	0.01	−0.08	−0.06	1.00				
Cap. Expend.	0.22	0.08	0.07	−0.11	1.00			
Seg. Diversif.	−0.05	−0.11	−0.07	0.58	−0.13	1.00		
Geog. Divers.	−0.05	0.07	−0.05	−0.64	0.02	−0.31	1.00	
Cust. Conc.	−0.16	−0.07	−0.13	−0.24	0.10	−0.21	0.33	1.00
Tech Coher.	0.22	0.15	0.16	−0.46	0.13	−0.31	0.30	0.13

Note: Since we are using a panel data, the correlation table might not be a good predictor of the regression relations, as it is likely driven by the cross-firm variation, rather the within variation. But it is included as complementary information about the nature of our data.

hypotheses must be able to exclude systematic differences in financial performance between adopters and non-adopters that arise from factors entirely outside of the focus of our study. In particular, measurement of the effect of process management requires a meaningful counterfactual, that is, a measure of what would have happened to that firm in the absence of adoption. One way to specify the counterfactual (to control for these differences between adopters and non-adopters) is to employ a matched pairs design, as Corbett et al. (2005) have done, with particular attention to matching firms based on similarity in their characteristics. While this may be possible when studying a cross-section of industries, it is a more difficult design to carry out in a single industry where the majority of firms eventually adopt the program. Since answering our research

Table 2
Impact of ISO 9000 adoption on firm performance—Firm Fixed Effects Model

Definition of adoption	Adoption 0–1			Firm trend after adoption		
Dependent variable	ROS 1	ROA 2	Tobin's *q* 3	ROS 4	ROA 5	Tobin's *q* 6
Adoption	0.0019 (0.41)	0.0002 (0.979)	0.1435 (0.03)**	0.0029 (0.12)	0.0068 (0.02)**	0.1339 (0.00)***
Log of sales	0.0082 (0.71)	0.0157 (0.374)	−0.2706 (0.09)*	0.0110 (0.34)	0.0241 (0.17)	−0.1599 (0.31)
Capital expenditures	0.0118 (0.3)	−0.0948 (0.12)	0.2620 (0.64)	0.0146 (0.71)	−0.0873 (0.15)	0.3765 (0.49)
Customer concentration	−0.0083 (0.51)	−0.0112 (0.659)	−0.0408 (0.86)	−0.0062 (0.7)	−0.0050 (0.84)	0.0370 (0.87)
Segment diversification	−0.0194 (0.89)	−0.0406 (0.227)	0.0130 (0.97)	−0.0205 (0.35)	−0.0441 (0.19)	−0.0325 (0.91)
Geographic diversification	0.0050 (0.34)	0.0232 (0.306)	0.3016 (0.14)	0.0049 (0.74)	0.0233 (0.3)	0.2945 (0.14)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	457	457	457	457	457	457
Groups	75	75	75	75	75	75
F statistic value	4.27 (0.00)***	4.56 (0.00)***	8.01 (0.03)**	4.45 (0.00)***	5.00 (0.00)***	10.03 (0.00)***
R square	0.15	0.16	0.25	0.15	0.17	0.29

p-Values in parenthesis; *significant at 10%; **significant at 5%; ***significant at 1%.
Regressions are cross-sectional time series data. They all include fixed effects for the firms in the sample as well as time dummies for every year; both sets are not reported in the table to save space and improve readability. The same procedure is followed in all other subsequent tables in the article.

questions requires that we study process management adoption in one industry, our approach is to assess how a particular firm's performance changes with its own adoption of process management. That is, we look at how performance changes within each firm following adoption, while controlling for contemporaneous changes in other firm characteristics that could also influence performance. A longitudinal panel data design with firm fixed effects and year controls accomplishes this (Hsiao, 1986), while also allowing the use of our full sample of firm-year data.

We then use the following model to test Hypothesis 1a:

$$\begin{aligned}\text{performance}_{it} &= \beta_0 \text{ISO\_adoption}_{it} + \beta_1 \ln\text{\_sales}_{it} + \beta_2 \text{capex}_{it} \\ &\quad + \beta_3 \text{div\_geo}_{it} + \beta_4 \text{div\_seg}_{it} + \beta_5 \text{cust\_cc}_{it} \\ &\quad + \sum_{k=1}^{9} \gamma_k \times \text{year\_dummies}_k + \alpha_i + \varepsilon_{it} \qquad (1)\end{aligned}$$

The dependent variable performance_{it} is the financial performance of firm i at time t, measured as either return on assets (ROA), return on sales (ROS) or Tobin's q. The independent variables are ISO 9000 adoption, a set of control variables that may influence firm performance, as described in the previous section, as well as year dummies to capture annual idiosyncratic shocks that can affect the performance of all firms (e.g. overall economic conditions). As explained above, the model also includes firm effects (α_i) to control for unobserved fixed firm heterogeneity.[6] A Hausman test rejected the hypothesis of an alternative random effects model. We ran these models in STATA, using the xtreg (fe) command.

The results from the base model (1) are presented in Table 2.[7] The table represents the coefficients and p-values for all our main regressors, as well as indications on the number of firms and total observations, the value of the F statistic and the R^2 of the regressions. Firm individual fixed effects and year dummy controls are also included (noted with a "yes" in the "Year Dummies" line), but following the conventional format, the table does not show all these coefficients. Moreover, tests on whether firm or time dummies are jointly zero are clearly rejected. Similar procedures were followed for all subsequent tables reporting regression results.

In columns (1)–(3) of Table 2, the adoption variable is zero until the year of the first certification of the firm and one from there onwards; the three columns correspond to the different performance metrics we are using. Hypothesis 1a, that adoption of ISO 9000 improves the performance of the average firm is supported for only for the Tobin's q metric. On the right hand side of Table 2, we use the individual firm trend since adoption, our alternative definition of ISO adoption to test the same hypothesis. In this case, and over time, certification has a significant effect on firm performance as measured by Tobin's q (as in the previous result), as well as on ROA, but still not on ROS. Overall, the estimates offer limited support for Hypothesis 1a. Yet, the stock market value of a firm appears to consistently increase with ISO 9000 certification, suggesting investors expect a higher stream of future profits for adopters than for the non-adopters. This may reflect stockholder expectations arising from the increased legitimacy resulting from ISO 9000 adoption, regardless of whether or not a given firm will realize these expected benefits.

Next we test Hypothesis 1b, that early adopters will benefit more from adopting ISO 9000. For this analysis, we divided earlier and later adopters according to the year when the majority (greater than 50%) of the firms in the industry became ISO 9000 certified. Our empirical strategy follows from the discussion leading to Hypothesis 1b. Firms have potential to gain some advantage from process management as a distinctive characteristic until most of its competitors have adopted. As Fig. 1 shows, by 1995, less than 40% of the firms in our sample had been certified, while in 1996 over 60% had adopted. Thus, we use 1995 as the cutoff. We created a dummy variable equal to one for earlier adopters (that is, firms that adopted in or before 1995) and equal to zero otherwise. We then included an interaction between the earlier adopter dummy variable and our ISO 9000 adoption variable in the regression model described in Eq. (1). Because the early adopter status is an individual firm characteristic with no variation over time, its direct effect is conditioned away by the firm fixed effects and as a result, only the interaction term (which includes a time component)

[6] Despite the use of fixed effects, bias could still occur if firms adopted ISO 9000 as a reaction to poor performance. In this case, ISO 9000 certification might be just one of several (unmeasured) activities undertaken by a firm to try to improve performance, and we would tend to overestimate the performance impacts of ISO 9000. To explore this, we ran a hazard model assessing the determinants of ISO 9000 adoption. These results, not reported, but available from the authors, show that firms that are doing better financially are more likely to adopt. This suggests that concerns that poor performance drives adoption is not a problem for our data.

[7] We ran the same model but with adoption values lagged 1 year and the results are similar to the ones reported.

Table 3
Impact of early ISO 9000 adoption[a]—Firm Fixed Effects Model

Definition of adoption	Adoption 0–1			Firm trend after adoption		
Dependent variable	ROS 1	ROA 2	Tobin's q 3	ROS 4	ROA 5	Tobin's q 6
Adoption	−0.0077 (0.25)	−0.0183 (0.08)*	−0.0519 (0.58)	−0.0050 (0.31)	−0.0099 (0.19)	0.075 (0.27)
Adoption × Until_95	0.0154 (0.05)*	0.0296 (0.01)***	0.3125 (0.00)***	0.0077 (0.08)*	0.0164 (0.02)**	0.0575 (0.35)
Log of sales	0.0105 (0.36)	0.0202 (0.25)	−0.2230 (0.16)	0.0110 (0.96)	0.0241 (0.17)	−0.1600 (0.31)
Capital expenditures	0.0091 (0.82)	−0.1000 (0.10)	0.2076 (0.71)	0.0095 (0.24)	−0.0979 (0.11)	0.3393 (0.53)
Customer concentration	−0.0052 (0.75)	−0.0053 (0.84)	0.0219 (0.92)	−0.0056 (0.34)	−0.0035 (0.89)	0.0421 (0.85)
Segment diversification	−0.0210 (0.33)	−0.0438 (0.19)	−0.0202 (0.95)	−0.0208 (0.96)	−0.0447 (0.18)	−0.0346 (0.91)
Geographic diversification	0.0070 (0.63)	0.0269 (0.23)	0.3415 (0.09)*	0.0059 (0.4)	0.0252 (0.26)	0.3013 (0.13)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	457	457	457	457	457	457
Groups	75	75	75	75	75	75
F statistic value	4.29 (0.00)***	4.73 (0.00)***	8.19 (0.00)***	4.38 (0.00)***	5.01 (0.00)***	9. 45 (0.00)***
R square	0.16	0.17	0.26	0.16	0.18	0.29

p-Values in parenthesis; *significant at 10%; **significant at 5%; ***significant at 1%.

[a] The magnitude and significance of the relevant coefficients are very similar if the cut-off year is 1994; exceptions are on the right hand since of the table, with the firm trend adoption variable: the significance level of the Adoption × Until _94 interaction disappears for ROS and the main trend coefficient for Tobin becomes significant.

remains in the final regression. The sign on this interaction term is precisely what we are interested in to understand the difference between early and late adopters. If there is no difference in the contribution to the average performance between those adopting early and later, then the interaction effect should not be explaining any variance beyond that of the main adoption effect and should therefore not be significant. If, on the contrary, the interaction is positive and significant, then we can conclude that early adopters gain a superior financial performance when adopting ISO.

We present the results in Table 3. Columns (1)–(3), which characterize adoption as a 0–1 variable, suggest that there is a benefit to early adopters of ISO 9000 when compared to the remaining group: The performance of the average firm that adopted ISO 9000 in or before 1995 is better than before it was first certified, and the result is significant for any of the performance measures. Another interesting observation is the fact that the early adopter interaction term captures all the positive effect arising from adoption. There are no positive impacts associated with the baseline adoption regressors. Moreover, the impact is relevant. For example, looking at the interaction coefficient for ROS (column 1), we can see that early adopters improve performance by 1.5%, a 20% gain from the average value reported in Table 1.

We obtain mostly similar results using the individual firm trend over time used to capture the lasting effect of ISO adoption (shown in columns (4)–(6) in Table 3). Performance benefits are driven by early adopters in the results for ROS and ROA, but not for Tobin's q, where there is no difference between adopters before and after 1995. A potential explanation for these different results lies in the nature of the Tobin's q measure. Since it embodies the market expectation of future profits, it is possible that most of the impact happens immediately (but reflects the discounted long-term increase in value) when the market receives the information that the ISO certification took place, rather than increasing gradually over time as improvement occurs. This would limit the potential to pick up the statistical effect in the trend specification for the Tobin's q measure, as we observe in Table 3.

These findings lend broad support for Hypothesis 1b. It is the distinctiveness of ISO 9000 adoption early on, when relatively few firms have ISO 9000 certifications, that appears to be driving the performance differences. As other competing firms also adopt, the unique advantage of adoption is lost. We also tested our results using 1994 instead of 1995 as the cutoff for early adopters. Results were mostly consistent with those obtained for 1995 (see notes in Table 3 for details).[8]

[8] We also considered an alternative specification where, instead of a cutoff year, we used a 'year of adoption' variable and subsequently interacted it with the adoption dummy. Results are consistent with those presented here.

Hypothesis 2 relates to the moderating effect of a firm's technology characteristics on the performance impact of process management adoption. Specifically, we hypothesize that neither very focused nor very diverse firms will benefit as much from the adoption of ISO 9000 as those in the middle range. To test these notions, we use the technology coherence metric described in the *Measures* section. That performance benefits of ISO 9000 practices will at first increase with greater technological breadth, but at some point this tendency will be inverted and performance benefits of ISO 9000 practices will be increasingly lower suggests an inverted U-shape relationship. Thus, we modified Eq. (1) to include a technology coherence regressor as well as the square of the coherence term. If the hypothesized curvilinear relation is indeed verified in the data, we expect to find a positive result in the linear term and a negative coefficient in the quadratic component of the coherence measure. We then interacted both with ISO adoption to single out the moderating role. Again, because the technology coherence metric is an individual firm characteristic with no cross time variation, its direct effect is conditioned away by the firm fixed effects and only the interaction terms remain. The new regression Eq. (2) is then:

$$\begin{aligned}\text{perform}_{it} = {} & \beta_0 \text{ISO\_adoption}_{it} \\ & + \beta_{01}\text{Tech\_Coh}_i * \text{ISO\_adoption}_{it} \\ & + \beta_{02}\text{Tech\_Coh}_i^2 * \text{ISO\_adoption}_{it} ** \\ & + \beta_1 \ln\_\text{sales}_{it} + \beta_2 \text{capex}_{it} + \beta_3 \text{div\_geo}_{it} \\ & + \beta_4 \text{div\_seg}_{it} + \beta_5 \text{cust\_cc}_{it} + \sum_{k=1}^{9} \gamma_k \\ & \times \text{year\_dummies}_k + \alpha_i + \varepsilon_{it} \qquad (2)\end{aligned}$$

In addition to the new specification, the evaluation of the impact of technology coherence also requires narrowing our sample of firms. The technology coherence data is only available for the auto industry segments of each firm. Yet our performance measures are at the firm level. This could be misleading since several companies also have segments outside the auto industry that influence firm performance. Thus, for testing H2, we restricted the sample to firms for which the auto segment represented more than 75% of total firm sales.[9] The new sample has 65 firms and 403 observations. To verify that this more focused group was consistent with the complete sample used to test Hypothesis 1a and Hypothesis 1b we redid the analysis presented in Table 3 for this smaller sample and the overall conclusions regarding the two Hypotheses were the same.

Table 4 presents the results of our analysis, again using the two definitions of ISO 9000 adoption. For either ROA or ROS as the performance measure, the coefficients on the technology coherence interaction term are positive, and are negative on the squared interaction term. This suggests indeed that firms with average levels of technology coherence have the best prospects for performance improvement upon adoption of ISO 9000. Moreover, since the main effect observed in the ISO adoption coefficient is negative, results suggest that firms with both low and high coherence may actually be penalized when they adopt ISO 9000. The results are similar using both definitions of adoption. The impact is also reasonably within range in terms of the coherence variable and the magnitude of the impact. For columns 1 and 2, the maximum impact on performance is reached for ISO adopters with a technology coherence levels between 0.55 and 0.6, values within one standard deviation of the 0.41 average for the variable. To have an idea of the magnitude of the impact, a more focused firm, for example with a technology coherence level of 0.2 (one standard deviation below the average) would benefit from ISO adoption (in terms of ROS) 0.029 less than an adopting firm with technology coherence 0.6. Given that the mean level of ROS is 0.078, these differences are relevant. The impacts in ROA are similar (slightly larger, as is the average of this variable). In addition, neither result holds for the Tobin's q measure. This suggests that while stockholders might anticipate benefits from ISO 9000 adoption (reflected in the earlier result), they may not recognize that a firm's technology characteristics impact its ability to leverage process management adoption.

Overall, Hypothesis 2 is supported. First, technological capabilities do moderate the impact of process management techniques on firm performance and second, firms that are highly focused or diversified technologically are less likely to benefit from these techniques. Nevertheless, the differences in accounting return measures and stock market based measures suggest that stockholders and the market might not recognize these differences. In addition, we ran specifications that interacted the technology coherence term (and its square) with the early adoption dummy and the results are robust to this distinction. The results for the impact of technology coherence on performance

[9] To test robustness, we also ran the same models only with firms where the auto segment represents 100% of the sales and overall results are similar, though significance levels are smaller in some cases due to fewer observations.

Table 4
ISO 9000 adoption and technology coherence—Firm Fixed Effects Model

Dependent variable	ROS	ROA	Tobin's q	ROS	ROA	Tobin's q
Adoption variable	0–1 adoption			Firm trend after adoption		
	1	2	3	4	5	6
Adoption	−0.0523 (0.00)***	−0.0657 (0.01)***	0.2255 (0.32)	−0.0236 (0.00)***	−0.0245 (0.04)**	0.1901 (0.09)*
Adoption × Tech Coh	0.2282 (0.00)***	0.2892 (0.001)***	0.0660 (0.95)	0.1306 (0.00)***	0.1640 (0.01)***	−0.2680 (0.64)
Adoption × Tech Coh Square	−0.1945 (0.00)***	−0.2520 (0.01)***	−0.7198 (0.46)	−0.1219 (0.00)***	−0.1623 (0.02)**	0.2109 (0.74)
Log of sales	0.0011 (0.93)	0.0066 (0.71)	−0.3568 (0.04)**	0.0069 (0.55)	0.0218 (0.22)	−0.2532 (0.13)
Capital expenditures	−0.0029 (0.39)	−0.0056 (0.29)	0.0072 (0.86)	−0.0028 (0.40)	−0.0052 (0.31)	0.0150 (0.76)
Customer concentration	−0.0171 (0.27)	−0.0248 (0.31)	−0.0362 (0.88)	−0.0130 (0.40)	−0.0143 (0.55)	0.0518 (0.82)
Segment diversification	−0.0033 (0.89)	−0.0123 (0.73)	0.1574 (0.65)	−0.0041 (0.86)	−0.0158 (0.66)	0.0398 (0.91)
Geographic diversification	−0.0031 (0.82)	0.0116 (0.56)	0.3154 (0.12)	0.0017 (0.90)	0.0171 (0.41)	0.3157 (0.10)*
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	403	403	403	403	403	403
Groups	65	65	65	65	65	65
F statistic value	6.09 (0.00)***	5.34 (0.00)***	8.44 (0.00)***	6.32 (0.00)***	5.88 (0.00)***	9.78 (0.00)***
R square	0.24	0.22	0.31	0.25	0.24	0.34

are not explained by earlier adoption. Moreover, there appears to be no difference in how technology coherence impacts performance between early and later adopters.

5. Discussion and conclusions

We extend existing research studying process management by exploring two questions that have been missing in prior studies. Drawing on literature in strategic management, we first explore how the expected performance benefits of process management practices, such as ISO 9000, may be competed away as most firms in an industry adopt. Second, we explore the firm-specific conditions under which these practices might lead to sustainable performance advantages.

We hypothesized and concluded that while performance advantages accrue for earlier adopters in an industry, they are competed away over time for later adopters. We further argued, however, that process management practices are not simply generic improvement practices; instead, they directly affect the linkages and fit among firms' activities. Thus, the effects of process management practices likely depend on differences in underlying capabilities. We hypothesized that the extent of coherence or relatedness in firms' underlying technologies would influence the performance benefits of process management utilization. Very narrow firms with only one or a few technologies will have limited opportunities for linking related activities to create unique, valuable, firm-specific combinations. Thus, we expect benefits for these firms to be less sustainable, as they are unlikely to lead to inimitable capabilities. As a firm increases the breadth of its technological capabilities, process management practices may help increase the fit among related activities, and may result in firm-specific complementarities and interactions between interdependent processes that are hard to imitate. However, as a firm's technologies become highly unrelated, the potential for complementary interactions that arises from relatedness is reduced; in addition it may be more difficult and costly to implement process management in disparate areas. Our results confirm this hypothesis. Specifically, firms with medium level of technology diversity, i.e. companies with a broad but not very diverse set of technologies systematically show gains from ISO 9000 adoption.

This study contributes to both the process management and strategy literature streams. Although strategy scholars have suggested that the advantages from adoption of best practices like process management will be competed away (e.g. Porter, 1996; Levinthal, 2000; Lieberman and Montgomery, 1988), such ideas have not been empirically tested with detailed panel data on process management practices. Similarly, work in strategic management has developed ideas about how relatedness or fit in firm capabilities affects sustainable advantage (e.g. Siggelkow, 2002), but again such research has not used widespread adoption of process management – with its focus on integrating firm activities – to test these ideas. By integrating these insights from strategy literature with data on process management adoption, our findings also help to provide plausible explanations for conflicting results in previous process management studies. We provide deeper insights into the conditions under which some firms are likely to benefit more from such practices. Our study of a longitudinal panel of firms in one industry also makes an important empirical contribution. Instead of cross-sections or broad control groups, we are able to study a comparable and competing set of firms in a sector over time during a period when ISO 9000 adoption became ubiquitous. These features of our empirical design help control for unobserved heterogeneity (and thus selection issues), often overlooked in previous studies. We use a unique dataset that includes objective third-party data on firms' process-focused activities and performance (helping to overcome the subjectivity of self-report survey data), in addition to firm-specific detail on technological capabilities.

This research also contributes to management practice. Managers often have been frustrated in their efforts to translate efficiency gains into expected financial performance advantages. Our findings suggest that although relative performance benefits from process management may become elusive as the majority of firms in an industry adopt, creating sustainable advantage from such techniques may be possible if firms use them to link related activities in unique, inimitable ways. Properly used, such practices may be a way for firms to integrate knowledge while mitigating its imitability (e.g. Coff et al., 2006).

Our study has limitations. Our results strongly show that performance advantages are lower for later adopters, suggesting that the potential for benefits disappears as the majority of firms in an industry adopt these practices. The time frame available in our data limits our ability to directly test whether the advantages for earlier adopters dissipate beyond the periods included in our study. Moreover, while we demonstrate that firms with some relatedness in their portfolio of technologies benefit the most from process management adoption, we again do not have a sufficient time frame to test whether these advantages are sustainable over a longer period. Our findings provide a first step toward answering deeper questions about the conditions under which process management advantages are sustainable, but future research could consider these questions over an even longer period. Another limitation is related to the fact that the data used in our study only goes until 1998, and therefore does not account for what has happened in the past decade in this sector. Since then, anecdotal evidence suggests there has been virtually a complete adoption of the norm in the automotive sector. Moreover, in 1999, the ISO/TS 16949 was approved as the first sector specific ISO 9000 adaptation, to be used in the auto supplier industry. The overall ISO 9000 norm also changed in 2000, becoming much more focused more on process improvement than earlier versions and thus the current conditions do not mirror the context of our work. Thus, any subsequent or related work would have to consider the impact of these changes.

Future work should explore equivalent questions in multiple industries. While the auto supply industry is ideal for studying the competitive effects of increasing process management use within an industry, the generality of our findings for other contexts is not clear. In industries where adoption of these practices has been slower and less widespread, it may be that firms are able to gain and sustain financial advantages from efficiency improvements. In particular, our findings may be more applicable to mature industries, characterized by a focus on incremental change and pressures for efficiency improvement. Prior research has also suggested that process management practices are most beneficial in stable or incrementally changing environments, and may be detrimental in a changing or turbulent environment (e.g. Sitkin et al., 1994; Sutcliffe et al., 2000; Benner and Tushman, 2003). Process management's focus on incremental learning and local search may inhibit more dramatic innovation and change required to adapt in changing environments (e.g. Sitkin et al., 1994; Levinthal and March, 1993; Benner and Tushman, 2002). A tighter fit in systems of activities, spurred by process management practices, while appropriate for performance improvements in stable environments, can also heighten inertia and maladaptive response in the face of environmental change (Levinthal, 1997; Hannan and Freeman, 1984). Thus, while managers may gain from using these practices to seamlessly coordinate related activities in mature environments, they must also exercise caution in undertaking these practices in changing environments.

Acknowledgements

We would like to thank Steven Klepper, Michael Lenox, Robert Lowe, Glenn Mercer, Pedro Oliveira, Rui Sousa, Nicolaj Siggelkow, Peter Thompson, Joel Waldfogel, Claudio Wolter as well as two anonymous referees and the editors for valuable comments and insights. We would also like to acknowledge suggestions from participants in seminars at Carnegie Mellon University, Massachusetts Institute of Technology, Universidade Católica Portuguesa and Faculdade de

Economia do Porto. Any errors remain our own. Francisco Veloso would like to acknowledge the support of the International Motor Vehicle Program and Fundacao para a Ciencia e Tecnologia in Portugal for this research, and Mary Benner would like to thank the Mack Center for Technological Innovation at The Wharton School for financial support.

References

Anderson, S.W., Daly, J.D., Johnson, M.F., 1999. Why firms seek ISO 9000 certification: regulatory compliance or competitive advantage? Production and Operations Management 8, 28–43.

Anderson, J.C., Rungtusanatham, M., Schroeder, R.G., 1994. A theory of quality management underlying the Deming management method. Academy of Management Review 19, 473–509.

Argyres, N.S., Silverman, B.S., 2004. R&D, organization structure, and the development of corporate technological knowledge. Strategic Management Journal 25, 929–958.

Barney, J., 1991. Firm resource and sustained competitive advantage. Journal of Management 17, 99–120.

Benner, M., Tushman, M., 2002. Process management and technological innovation: a longitudinal study of the photography and paint industries. Administrative Science Quarterly 47, 676–706.

Benner, M., Tushman, M., 2003. Exploitation, exploration and process management: the productivity dilemma revisited. Academy of Management Review 28, 238–256.

Berry, C.H., 1975. Corporate Growth and Diversification. Princeton University Press.

Benson, G., Saraph, J., Schroeder, R., 1991. The effects of organizational context on quality management: an empirical investigation. Management Science 37 (9), 1107–1124.

Breschi, S., Lissoni, F., Malerba, F., 2003. Knowledge-relatedness in firm technological diversification. Research Policy 32, 69–87.

Casadesus, M., Karapetrovic, S., 2005. The erosion of ISO 9000 benefits: a temporal study. The International Journal of Quality & Reliability Management 22, 120–136.

Chatterjee, S., Wernerfelt, B., 1991. The link between resources and type of diversification: theory and evidence. Strategic Management Journal 12, 33–48.

Coff, R., Coff, D., Eastvold, R., 2006. The knowledge leveraging paradox: how to achieve scale without making knowledge imitable. Academy of Management Review 31, 452–465.

Cole, R.E., 1998. Learning from the quality movement: what did and did not happen and why? California Management Review 41 (1), 43–73.

Corbett, C., 2002. Diffusion of ISO 9000 and ISO 14000 certification through global supply chains. UCLA Working Paper.

Corbett, C., Montes-Sancho, M., Kirsch, D., 2005. The financial impact of ISO 9000 certification: an empirical analysis. Management Science 51 (7), 1046–1059.

Das, A., Handfield, R.B., Calantone, R.J., 2000. A contingent view on quality management—the impact of international competition on quality. Decision Science 31 (3), 649–690.

Dean Jr., J.W., Bowen, D.E., 1994. Management theory and total quality: improving research and practice through theory development. Academy of Management Review 19, 392–418.

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

DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited: institution isomorphism and collective rationality in organizational fields. American Sociological Review 48, 147–160.

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

Dosi, G., Nelson, R., Winter, S., 2000. Introduction. In: Dosi, G., Nelson, R., Winter, S. (Eds.), The Nature and Dynamics of Organizational Capabilities. Oxford University Press, Oxford, pp. 1–22.

Easton, G.S., Jarrell, S.L., 1998. The effects of total quality management on corporate performance: an empirical investigation. Journal of Business 71, 253–307.

Eisenhardt, K., Martin, J., 2000. Dynamic capabilities: what are they? Strategic Management Journal 21, 1105–1121.

Ettlie, J., 1997. Quality, technology, and global manufacturing. Production and Operations Management 6 (2), 150–166.

Gambardella, A., Torrisi, S., 1998. Does technological convergence imply convergence in markets? Evidence from the electronics industry. Research Policy 27, 445–463.

Garvin, D.A., 1991. How the Baldrige Award really works. Harvard Business Review 69 (6), 80–93.

Garvin, D.A., 1995. Leveraging processes for strategic advantage. Harvard Business Review 73 (5), 77–90.

Guler, I.M., Guillen, J., MacPherson, 2002. Global competition, institutions, and the diffusion of organizational practices: the international spread of the ISO 9000 quality certificates. Administrative Science Quarterly 47, 207–232.

Hackman, J.R., Wageman, R., 1995. Total quality management: empirical, conceptual, and practical issues. Administrative Science Quarterly 40, 309–342.

Hammer, M., Champy, J., 1993. Reengineering the Corporation: A Manifesto for Business Revolution. HarperBusiness, New York.

Hannan, M.T., Freeman, J., 1984. Structural inertia and organizational change. American Sociological Review 49, 149–164.

Harrington, H.J., Mathers, D.D., 1997. ISO 9000 and Beyond: From Compliance to Performance Improvement. McGraw-Hill, New York.

Harry, M., Schroeder, R., 2000. Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations. Currency, New York.

Haversjo, T., 2000. The financial effects of ISO 9000 registration for Danish companies. Managerial Auditing Journal 15, 47–52.

Heaphy, M.S., Gruska, G.F., 1995. The Malcolm Baldrige National Quality Award. Addison-Wesley.

Hendricks, K., Singhal, V., 1996. Quality awards and the market value of the firm: an empirical investigation. Management Science 42, 415–436.

Hendricks, K., Singhal, V., 1997. Does implementing an effective TQM program actually improve operating performance? Empirical evidence from firms that have won quality awards. Management Science 43, 1258–1274.

Hendricks, K., Singhal, V., 2001. The long-run stock price performance of firms with effective TQM programs. Management Science 47, 359–368.

Heras, I., Casadesus, M., Dick, G., 2002a. ISO 9000 certification and the bottom line: a comparative study of the profitability of Basque region companies. Managerial Auditing Journal 17, 72–78.

Heras, I., Dick, G., Casadesus, M., 2002b. ISO 9000 registration's impact on sales and profitability: a longitudinal analysis of performance before and after accreditation. The International Journal of Quality & Reliability Management 19, 774–791.

Hill, C.W.L., Hoskisson, R.E., 1987. Strategy and structure in the multiproduct firm. Academy of Management Review 12, 331–341.

Hsiao, C., 1986. Analysis of Panel Data. Cambridge University Press.

International Organization for Standardization (ISO), 2007. http://www.iso.org/iso/en/iso9000-14000/understand/basics/general/basics_1.html.

Ittner, C.D., Larcker, D., 1997. The performance effects of process management techniques. Management Science 43, 522–534.

Jaffe, A.B., 1989. Characterizing the ‘‘technological position’’ of firms, with application to quantifying technological opportunity and research spillovers. Research Policy 18, 87–97.

Lang, L.H.P., Stulz, R.M., 1994. Tobin's q, corporate diversification, and firm performance. Journal of Political Economy 102 (6), 1248–1280.

Levinthal, D., March, J., 1993. The myopia of learning. Strategic Management Journal 14, 95–112.

Levinthal, D., 1997. Adaptation on rugged landscapes. Management Science 43 (7), 934–950.

Levinthal, D., 2000. Organizational capabilities in complex worlds. In: Dosi, G., Nelson, R., Winter, S. (Eds.), The Nature and Dynamics of Organizational Capabilities. Oxford University Press, pp. 363–376.

Levitt, B., March, J.G., 1988. Organizational learning. Annual Review of Sociology 14, 319–340.

Lieberman, M., Montgomery, D., 1988. First-mover advantages. Strategic Management Journal 9, 41–58.

Lima, M., Resende, M., Hasenclever, L., 2000. Quality certification and performance of Brazilian firms: an empirical study. International Journal Production Economics 66, 143–147.

Meyer, J.W., Rowan, B., 1977. Institutionalized organizations: formal structure as myth and ceremony. American Journal of Sociology 83, 340–363.

Miller, D.J., 2004. Firms' technological resources and the performance effects of diversification: a longitudinal study. Strategic Management Journal 25, 1097–1119.

Miller, J.G., Roth, A.V., 1994. A taxonomy of manufacturing strategies. Management Science 40 (3), 285–304.

Morris, P.W., 2006. ISO 9000 and financial performance in the electronics industry. Journal of American Academy of Business, Cambridge 8 (2), 227–235.

Montgomery, C., Wernerfelt, B., 1988. Diversification, ricardian rents, and Tobin's q. RAND Journal of Economics 19, 623–632.

Mukherjee, A., Lapré, M., Van Wassenhove, L., 1998. Knowledge driven quality improvement. Management Science 44, S35–S49.

Naveh, Eitan, Marcus, Alfred, 2005. Achieving competitive advantage through implementing a replicable management standard: installing and using ISO 9000. Journal of Operations Management 24 (1), 1–26.

Nicolau, J.L., Sellers, R., 2002. The stock market's reaction to quality certification: empirical evidence from Spain. European Journal of Operational Research 142, 632–641.

Pande, P., Neuman, R., Cavanagh, R., 2000. The Six Sigma way: How GE, Motorola and Other Top Companies are Honing Their Performance. McGraw-Hill, New York.

Patel, P., Pavitt, K., 2000. How technological competencies help define the core (not the boundaries) of the firm. In: Dosi, G., Nelson, R., Winter, S. (Eds.), The Nature and Dynamics of Organizational Capabilities. Oxford University Press, pp. 313–333.

Peteraf, M.A., 1993. The cornerstones of competitive advantage: a resource-based view. Strategic Management Journal 14, 179–192.

Porter, M., Siggelkow, N., 2004. Contextual interactions within activity systems and sustainable competitive advantage. The Wharton School Working Paper.

Porter, M., 1996. What is strategy? Harvard Business Review 74 (6), 61–78.

Powell, T.C., 1995. Total quality management as competitive advantage: a review and empirical study. Strategic Management Journal 16, 15–37.

Repenning, N., Sterman, J., 2002. Capability traps and self-confirming attribution errors in the dynamics of process improvement. Administrative Science Quarterly 47, 265–295.

Rumelt, R., 1982. Diversification strategy and profitability. Strategic Management Journal 3 (4), 359–369.

Samson, D., Terziovski, M., 1999. The relationship between total quality management practices and operational performance. Journal of Operations Management 17, 393–409.

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

Siggelkow, N., 2002. Evolution toward fit. Administrative Science Quarterly 47, 125–159.

Silverman, B.S., 1999. Technological resources and the direction of corporate diversification: toward an integration of the resource-based view and transaction cost economics. Management Science 45, 1109–1124.

Simmons, B.L., White, M.A., 1999. The relationship between ISO 9000 and business performance: does registration really matter? Journal of Managerial Issues 11 (3), 330–343.

Singh, H., Montgomery, C., 1987. Corporate acquisition strategies and economic performance. Strategic Management Journal 8 (4), 377–386.

Sitkin, S.B., Sutcliffe, K.M., Schroeder, R.G., 1994. Distinguishing control from learning in total quality management: a contingency perspective. Academy of Management Review 19, 537–564.

Sousa, R., 2003. Linking quality management to manufacturing strategy: an empirical investigation of customer focus practices. Journal of Operations Management 21, 1–18.

Sousa, R., Voss, C., 2002. Quality management re-visited: a reflective review and agenda for future research. Journal Operations Management 20 (2002), 91–109.

Staw, B., Epstein, L.D., 2000. What bandwagons bring: effects of popular management techniques on corporate performance, reputation and CEO pay. Administrative Science Quarterly 45, 523–556.

Steinemann, P.P., 2000. Economic performance of product and process firms: focus and diversification in the automotive supplier industry. Ph.D. dissertation. Massachusetts Institute of Technology.

Sterman, J.D., Repenning, N.P., Kofman, F., 1997. Unanticipated side effects of successful quality programs: exploring a paradox of organizational improvement. Management Science 43, 503–521.

Sturgeon, Timothy, J., Florida, Richard, L., 1997. Research note: the globalization of automobile production. International Motor Vehicle Program, MIT, Cambridge, MA.

Sutcliffe, K., Sitkin, S., Browning, L., 2000. Tailoring process management to situational requirements. In: Cole, R., Scott, W. (Eds.), The Quality Movement & Organization Theory. Sage, London, pp. 315–330.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18, 509–533.

Teece, D., Dosi, G., Rumelt, R., Winter, S., 1994. Understanding corporate coherence. Journal of Economic Behavior and Organization 23, 1–30.

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

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.

Terziovski, M., Power, D., Sohal, A., 2003. The longitudinal effects of the ISO 9000 certification process on business performance. European Journal of Operational Research 146, 580–595.

Wayhan, V.B., Kirche, E.T., Khumawala, B.M., 2002. ISO certification: the financial performance implications. Total Quality Management 13 (2), 217–231.

Westphal, J.D., Gulati, R., Shortell, S.M., 1997. Customization or conformity? An institutional and network perspective on the content and consequences of TQM adoption. Administrative Science Quarterly 42, 366–394.

White, G., 1996. A meta-analysis model of manufacturing capabilities. Journal of Operations Management 14, 315–331.

Winter, S., 1994. Organizing for continuous improvement: evolutionary theory meets the quality revolution. In: Baum, J., Singh, J. (Eds.), Evolutionary Dynamics of Organizations. Oxford University Press, New York.

Wolter, C., Veloso, F., Steinemann, P., 2003. Technological diversification and economic performance: a within-industry perspective. Working Paper. Carnegie Mellon University.

Wruck, K., Jensen, M., 1994. Science, specific knowledge, and total quality management. Journal of Accounting and Economics 18, 247–287.

Zbaracki, M.J., 1998. The rhetoric and reality of total quality management. Administrative Science Quarterly 43, 602–636.

Zucker, L.G., 1986. Production of trust: institutional sources of economic structure, 1840–1920. Research in Organizational Behavior 8, 53–111.