J PROD INNOV MANAG 2009;26:473–486

Dynamic or Static Capabilities? Process Management Practices and Response to Technological Change*

Mary J. Benner

Whether and how organizations adapt to changes in their environments has been a prominent theme in organization and strategy research. Within this research, there is controversy about whether organizational routines hamper or facilitate adaptation. Organizational routines give rise to inertia but are also the vehicles for change in recent work on dynamic capabilities. This rising interest in routines in research coincides with an increase in management practices focused on organizational routines and processes. This study explores how the increasing use of process management practices affected organizational response to a major technological change through new product developments. The empirical setting is the photography industry over a decade, during the shift from silver-halide chemistry to digital technology. The advent and rise of practices associated with the new ISO 9000 certification program in the 1990s coincided with increasing technological substitution in photography, allowing for assessing how increasing attention to routines through ISO 9000 practices over time affected ongoing responsiveness to the technological change. The study further compares the effects for the incumbent firms in the existing technology with nonincumbent firms entering from elsewhere. Relying on longitudinal panel data models as well as hazard models, findings show that greater process management practices dampened response to new generations of digital technology, but this effect differed for incumbents and nonincumbents. Increasing use of process management practices over time had a greater negative effect on incumbents' response to the rapid technological change. The study contributes to research in technological change by highlighting specific management practices that may create disconnects between firms' capabilities and changing environments and disadvantage incumbents in the face of radical technological change. This research also contributes to literature on organizational routines and capabilities. Studying the effects of increasing ISO 9000 practices undertaken in firms provides an opportunity to gauge the effects of systematic routinization of organizational activities and their effects on adaptation. This research also contributes to management practice. The promise of process management is to help firms adapt to changing environments, and, as such, managers facing technological change may adopt process management practices as a response to uncertainty and change. But managers must more fully understand the potential benefits and risks of process management to ensure these practices are used in the appropriate contexts.

Introduction

Adapting to a major environmental change is an important challenge for organizations, and how organizations evolve and adapt in changing environments has been a prominent theme in organization and strategy research (e.g., Hannan and Freeman, 1984; Henderson, 1993; Levinthal, 1991; Levinthal and March, 1993; March, 1991; Tushman and Romanelli, 1985). An underlying tension in recent research concerns whether organizational routines help or hinder firms' innovation and adaptation. A long stream of research suggests that routines give rise to inertia and constrain nonincremental organizational changes required to respond to radical environmental change (e.g., Hannan and Freeman; Leonard-Barton, 1992; Levinthal and March; Tushman and Romanelli). But recently, research on dynamic capabilities highlights the potential for routines to spur organizational change and innovation (e.g., Dosi, Nelson, and Winter, 2000; Eisenhardt and Martin, 2000; Levinthal, 2000; Teece, Pisano, and Shuen, 1997; Winter, 2003; Zollo and Winter, 2002).

This growing interest in organizational routines in research coincides with widespread diffusion of management practices focused on organizational routines

Address correspondence to: Mary J. Benner, Management Department, The Wharton School, University of Pennsylvania, 2010 Steinberg Hall - Dietrich Hall, Philadelphia, PA 19104-6370. Tel.: (215) 746-5719. Fax: (215) 898-0401. E-mail: benner@wharton.upenn.edu.

* Thanks to Jamie Eggers and Dan Levinthal for helpful suggestions on earlier versions of the manuscript, to Giancarlo Mott for research assistance, and to the Mack Center for Technological Innovation at the Wharton School for financial support. The author also greatly appreciates the thoughtful comments of the editor, Anthony Di Benedetto, and two anonymous reviewers.

and operating processes. In the past few decades, thousands of firms have adopted a process orientation and systematic procedures for refining, improving, and adhering to codified operating processes (Quality Digest, 2009). These practices are the core elements of many popular management programs, including total quality management (TQM), the ISO 9000 certification program, the Malcolm Baldrige Criteria, and Six Sigma programs (e.g., Benner and Tushman, 2003; Garvin, 1991; Ittner and Larcker, 1997; Sutcliffe, Sitkin, and Browning, 2000; Winter, 2000).

Studying the influence of process management practices offers a way to better understand the effects of increasing routinization on organizational response to environmental change (e.g., Benner and Tushman, 2003), yet very little research has taken advantage of this opportunity. Most research on process management practices has aimed at verifying the expected performance benefits from adopting a TQM program (e.g., Easton and Jarrell, 1998; Ittner and Larcker, 1997; Powell, 1995; Samson and Terziovski, 1999), getting ISO 9000 certified (e.g., Corbett, Montes-Sancho, and Kirsch, 2005), or winning a quality award (Hendricks and Singhal, 1996). Despite expectations of universal benefits, however, the results of such research have been inconclusive. For example, although some studies have found benefits of process management activities (e.g., Corbett et al.; Easton and Jarrell; Ittner and Larcker), these benefits do not necessarily translate into improvements in financial performance (Sterman, Repenning, and Kofman, 1997; Wruck and Jensen, 1994) or help firms in all contexts (Ittner and Larcker). Benner and Veloso (2008) studied how the benefits of process management practices dissipate in an industry as the majority of firms adopt similar techniques. In addition, they explored the role of technological coherence or relatedness in the performance benefits of process management. Firms with moderate levels of relatedness were able to use process management techniques to tighten linkages and create valuable, hard-to-imitate interactions and complementarities among processes. In other studies, the benefits of process management programs arise not from the actual process improvement practices but from other elements associated with such programs, like executive involvement or a culture supportive of quality (e.g., Cameron and Barnett, 2000; Powell; Samson and Terziovski).

A small number of studies have gone beyond assumptions that a process-focused approach will benefit organizations to explore the potential for negative outcomes from increased attention to processes. Some researchers have argued for a contingency view, proposing that process control practices are appropriate for incremental change or in stable environments but are inconsistent with the exploratory search and learning required in turbulent environments (Benner and Tushman, 2003; Sitkin, Sutcliffe, and Schroeder, 1994; Sutcliffe et al., 2000). In an empirical study of the effects of process management on firms' innovation through patents, Benner and Tushman (2002) found increasing process management practices in a firm associated with increases in exploitative patents that used familiar to the firm knowledge but with decreases in more exploratory innovations that relied on new knowledge. A firm's prior inventions often drive adaptation in the face of environmental change (e.g., Cohen and Levinthal, 1990; March, 1991; Nelson and Winter, 1982; Tushman and Nelson, 1990). Thus, it is likely that process management practices affect firms' responses to a technological change. Response to new technology is often accomplished through the development and commercialization of new products (Eisenhardt and Martin, 2000; Eisenhardt and Tabrizi, 1995). Yet this has not been studied in prior research. The present study undertakes that task and addresses the following question: How do process management practices affect the new product introductions required to respond to technological change? A dynamic capability is often defined ex ante as a higher-order systematic organizational practice focused on improving underlying operating routines and capabilities (e.g., Winter and Zollo, 2002). Process management activities are pervasive in organizations and are a common manifestation of such metaprocesses. Thus, studying the effect of such practices on response to environmental change provides an opportunity to understand the outcomes associated with such practices and whether they are associated with adaptation and change consistent with the promise of dynamic capabilities.

BIOGRAPHICAL SKETCH

Dr. Mary J. Benner is assistant professor of management in the Wharton School at the University of Pennsylvania. She holds a Ph.D. from Columbia University and an M.B.A. from Stanford University's Graduate School of Business. Her research explores the factors that affect technological innovation and established firms' responses to threatening technologies. Her research has been published in *Administrative Science Quarterly*, *Academy of Management Review*, *Organization Science*, *Research Policy*, *Industrial and Corporate Change*, and elsewhere. Prior to receiving her Ph.D., she held several marketing management and general management positions with Honeywell.

The empirical setting is the photography industry during the shift to digital technology. Data on ISO 9000 certifications were used to measure the increasing attention to process-focused activities and associated routinization in organizations, whereas data on new product introductions of digital cameras were used to measure firms' ongoing responsiveness to the changes in technology. The empirical design includes longitudinal panel data models with annual counts of digital camera products as well as hazard models. The advent and rise of the new ISO 9000 certification program and associated practices in the 1990s coincided with increasing technological substitution in photography, allowing for assessing how greater organizational routinization over time affected responsiveness. Further, the study compares how process management practices differentially influenced response to the same technological change for incumbents and nonincumbent entrants diversifying from other industries.

By empirically exploring the effects of popular, ubiquitous management practices on organizational outcomes, this work extends and contributes to research in several ways. It contributes to the technological change literature by highlighting the specific management practices that may create disconnects between firms' capabilities and changing environments and may disadvantage incumbents in the face of radical change in technology (cf. Schumpeter, 1942; Teece et al., 1997). This research also contributes to literature on organizational routines and capabilities. Studying the effects of increasing ISO 9000 practices undertaken in firms provides an opportunity to gauge the effects of systematic routinization of organizational activities and their effects on adaptation. This research also contributes to management practice. The promise of process management is to help firms adapt to changing environments (e.g., Pande, Neuman, and Cavanagh, 2000). Managers facing technological change may even be encouraged to adopt process management as a response to uncertainty and change. But managers must more fully understand the potential benefits and risks of process management to ensure these practices are used in the appropriate contexts.

ISO 9000 and Organizational Routinization

Recent attention to processes and routines in firms has been driven by a view of organizations as systems of interlinked processes that cross functional boundaries, accompanied by a belief that organizational improvement is best achieved through attention to rationalizing—and adhering to—an organization's underlying operating processes (Anderson, Rungtusanatham, and Schroeder, 1994; Dean and Bowen, 1994). Several well-known process management programs like TQM, ISO 9000, and Six Sigma comprise a shared set of systematic practices (e.g., ISO, 2009; Uzumeri, 1997): Organizational participants first document the organization's existing processes and then improve processes by eliminating wasted steps and tightly linking the handoffs between operating processes across the organization. For example, continuous improvement in an organization's manufacturing process requires greater integration with—and seamless handoffs from—the new product development process upstream. Correspondingly, improvements in service processes downstream require tighter integration with upstream manufacturing processes and so on. The last stage of process management is adherence to improved "best practices" to ensure an organization can realize the efficiency and quality benefits of well-understood, repeatable processes (e.g., Adler, 1993; Benner and Tushman, 2003; Cole, 1998; Hackman and Wageman, 1995; Hammer and Champy, 1993; Harry and Schroeder, 2000; Heaphy and Gruska, 1995). The initial "performance" of an operating process and the effects of subsequent improvements are often gauged using statistical techniques (e.g., Harry and Schroeder; Hackman and Wageman) with measures of time to market for new products, manufacturing yields and waste, and customer satisfaction (e.g., Harry and Schroeder; Pande et al., 2000; Sterman et al., 1997).

Process-focused practices are expected to improve efficiency (e.g., by improving manufacturing yields or reducing waste) as well as quality and customer satisfaction (e.g., Sterman et al., 1997; Wruck and Jensen, 1994). In addition, process-focused techniques are expected to help organizations achieve faster times to market for new products (e.g., Sterman et al.) and respond to rapid environmental change (Pande et al., 2000).

The ISO 9000 certification program, the empirical focus of this study, was widely adopted by organizations during the 1990s and is based on process focused practices. The ISO 9000 program stresses codifying and adhering to operating processes, reflected in the common motto: "Document what you do; do what you document" (ISO, 2009). To receive an ISO 9000 certification for operating processes such as manufacturing, new product development, or service, an organization must first demonstrate that it has documented the steps in the process and then must subsequently demonstrate that it is adhering to the process each time the activity is carried out. Certifications are issued by third-party registrars who audit the organization to ensure that processes have been mapped and are followed. Thus, ISO 9000 certifications indicate that a firm's processes have been codified and are repeatable. Firms can certify as many processes as they choose. An underlying assumption in this study is that the more certifications received by an organization, the greater its attention to—and scope of—process-oriented activities.

Thousands of organizations have undertaken the process-focused activities required for some level of ISO 9000 certification (cf. Benner and Tushman, 2002). Although process management practices were first applied to manufacturing processes, measurable efficiency gains from initial applications often spur the spread of process-oriented practices to other organizational areas and functions such as product development, purchasing, or resource allocation processes, among others (e.g., Cole and Scott, 2000; Garvin, 1995; Hammer and Stanton, 1999; Harry and Schroeder, 2000). As process-focused practices increase the routinization in organizational activities, it is important to understand how these practices affect response and adaptation in changing environments.

Technological Change in the Photography Industry

Technological change often necessitates change in firms' knowledge and capabilities (cf. Helfat, 2000) and, as such, provides an ideal setting for considering how the increased routinization arising from process management practices affects organizational response to change. Prior research has frequently focused on the challenge of radical technological changes that threaten to substitute for the existing technology in an industry and to destroy the value of accumulated technological knowledge and capabilities for the incumbent firms in an industry (e.g., Cooper and Smith, 1992; Hill and Rothaermel, 2003; Lavie, 2006; Rosenbloom, 2000; Tripsas, 1997; Tripsas and Gavetti, 2000; Tushman and Anderson, 1986). Radical technological change involves a shift to an entirely new technological trajectory that promises a superior price/performance frontier for the products in an industry (e.g., Gatignon et al., 2002; see also Dahlin and Behrens, 2005). Examples of radical technological change include the shift from mechanical escapement technology to quartz in the watch industry (Glasmeier, 1991; Landes, 1983), from steam to diesel-electric locomotives (Cooper and Smith), and from ice harvesting to mechanical refrigeration (Utterback, 1994), among others.

A cycle of technological change begins with an initial technological discontinuity (Tushman and Anderson, 1986; Utterback, 1994), that is, typically the first commercialization of a product incorporating the new technology. This event triggers rapid technological innovation marked by the entry of new competitors and increased uncertainty (Abernathy and Utterback, 1978; Tushman and Anderson; Utterback, 1994). During this "era of ferment," incumbent firms are challenged both with developing new knowledge and capabilities required to shift to a new technological trajectory as well as keeping up with rapid technological innovation as the new technology improves in both price and performance and increasingly substitutes for the old technology. The rapid pace of technological change and improvement during an "era of ferment" echoes research on high-velocity environments that involve rapid technological improvement (e.g., Brown and Eisenhardt, 1997; Eisenhardt and Martin, 2000; Eisenhardt and Tabrizi, 1995).

Similarly, in the setting in the present study, the advent of digital technology triggered radical and rapid technological change in photography. Digital technology represents a radical and competence-destroying technological change for incumbent firms in photography, as it requires that incumbent firms shift from knowledge and capabilities in chemistry-based film and analog technologies to digital knowledge and associated capabilities (e.g., Tripsas and Gavetti, 2000). Digital camera technology involves charged-coupled devices (CCDs) that convert light images to binary data and offers the future promise of superior price and performance for image capture, transfer, manipulation, and storage. From its advent, digital technology threatened to substitute and render the prior technologies obsolete.

In May 1991, Kodak introduced the DCS 100 digital camera. (Other electronic cameras were available in the 1980s, but these were based on analog, "still video" technology, not digital CCDs; Shippey, 1993). These early digital cameras were expensive (often in the \$20,000 to \$30,000 range) and were targeted to professional photographers. This first commercialization of digital technology in cameras triggered widespread speculation by photography industry experts and observers that digital technology would substitute for film (e.g., Aaland, 1993). Yet at such high prices, digital cameras had not yet achieved superior price and performance relative to film technology so did not immediately offer a viable substitute for consumers' use of film.

A marked improvement in the price/performance frontier in digital technology occurred with the introduction of the Apple QuickTake digital camera in April 1994. The QuickTake was the first point-and-shoot digital camera targeted to the under $1,000 consumer market. In the mid 1990s, following this event, numerous firms entered the consumer digital camera market, including film firms like Agfa, Kodak, and Fuji Photo, consumer electronics firms like Sony and Casio, and computer and peripherals manufacturers like Hewlett Packard and Canon. The period following the introduction of the Apple QuickTake was further characterized by rapid technological improvement as new generations of cheaper, smaller digital camera chips with higher resolution (measured in pixels) replaced previous generations. These technological improvements in the size, cost, and resolution of the CCDs (the digital chips) occurring outside the digital camera market triggered rapid improvements in the resolution performance and price of digital cameras: one-megapixel (million-pixel) cameras were available for less than $1,000 in 1997 and for less than $500 by 1998; two-megapixel cameras were available in 1998 and for less than $500 by 1999; three-megapixel cameras were available for under $1,000 in 2000; four-megapixel cameras were available for under $1,000 in 2001; five-megapixel cameras were available for under $1,000 in 2002; and six-megapixel cameras were available for less than $1,000 in 2003. Thus, annual improvements in resolution coupled with rapid reductions in prices proceeded throughout the mid 1990s and early 2000s. Participation in the digital camera market required ongoing, rapid response through new product development to continually adapt to changes in technology.

ISO 9000 and Firms' Responses to Technological Change

Incremental improvements in existing organizational routines are likely adaptive when the technology underlying an industry is characterized by the incremental product or process innovation that follows the emergence of a dominant standard (e.g., Anderson and Tushman, 1990; Suarez and Utterback, 1995; Utterback, 1994). However, new product innovations that require broader and more fundamental changes in the organization's goals or skills and may be inconsistent with practices focused on incrementally enhancing processes (Abernathy, 1978; Abernathy and Utterback, 1978). The practices focused on codifying and adhering to existing organizational operating processes that underlie ISO 9000 certifications are thus likely to be adaptive for incremental technological change but restrict larger-scale change in routines and capabilities. More generally, work in organizational learning suggests that organizations have difficulty balancing activities that exploit existing capabilities with innovation in new domains (Levinthal and March, 1993; Levitt and March, 1988; March, 1991). Process management practices and associated tools may shift the balance to more incremental, certain exploitation (e.g., Benner and Tushman, 2002). Evidence from prior research supports the idea that an incremental focus on existing processes can limit larger-scale changes required to respond to nonincremental technological change. For example, firms in the photolithographic alignment equipment industry responded inappropriately to nonincremental technological changes with incremental extensions of the current technology (Henderson and Clark, 1990). Adherence to standard resource allocation processes also hampered firms' appropriate responses to new technologies that departed from the requirements of existing customers (Christensen and Bower, 1996). Case studies provide additional evidence of the constraints created by the incremental focus of process management practices. After undertaking a TQM program focused on continuous process improvement, Alcoa's chief executive officer (CEO) stressed the need for a "rapid quantum-leap improvement" to overcome a "major mistake in our advocacy of the idea of continuous improvement" (Kolesar, 1993, p. 161). Similarly, while Analog Devices achieved measurable increases in efficiency as it implemented a process improvement program, a major reorganization was subsequently required to develop new products for new markets outside the core business (Sterman et al., 1997, p. 505).

Whether the process focused practices underlying ISO 9000 certification are beneficial for adaptation depends on the nature of the technological change. Consistent with prior work (e.g., Lavie, 2006), the extent of the change in capabilities required to adapt to a technological change is likely to differ for firms with different configuration of prior capabilities. For the incumbent firms with knowledge and capabilities in the existing technology, the application of process management practices creates measurable improvements in operational processes associated with the existing technology. These improvements contrast with the uncertain, underdeveloped, and hard-to-measure activities associated with activities in a new technology (cf. Levinthal and March, 1993). Organizational activities to develop knowledge and skills in the new technology can appear increasingly unattractive (Levinthal and March, 1993; Levitt and March, 1988), hindering commitment to the new technology.

Moreover, to the extent that incumbents engage in concerted efforts to improve efficiency, the overall price/performance frontier of the existing film technology also improves, allowing it to compete successfully with the new technology over a longer period, delaying substitution. These dynamics can further reinforce managers' mental models that the new technology is inferior (e.g., Tripsas and Gavetti, 2000). In the photography industry, ideas about improvements in the price and performance of film relative to digital technology are reflected in a quote from a Kodak executive: "We joke around here that film will only be in trouble when someone comes out with a $6.95 digital camera" (Austen, 2002). Even if an incumbent firm initially responds by introducing products based on the new technology, improvement in the existing technology may attenuate its commitment to the ongoing innovation required to keep pace with rapid technological change. Research has highlighted the many incumbent firms that entered a new technological domain but exited or failed in the new technology (Cooper and Smith, 1992). Thus, in the setting, the measurable benefits of process management practices in improving operating processes associated with the existing technology can restrict the development of new capabilities and commitment to respond to the new technology and can hamper an incumbent's ongoing response to the technological change.

H1: Increasing process management activities within incumbent firms (i.e., firms in analog and film technology) will be associated with less responsiveness to digital technology through new products.

But the implications of increased routinization through ISO 9000 practices are likely to differ for firms entering from different technological domains with different sets of prior knowledge and capabilities. The incumbent firms in the old technology are faced with an exogenous threat and have little choice but to respond or become obsolete, even though responding may require radically new capabilities. In contrast, firms entering from other domains are likely to enter the market created by the new technology when they have an opportunity to extend related capabilities (e.g., Helfat and Lieberman, 2002; Singh and Montgomery, 1987). In the photography setting, firms entered digital photography from consumer electronics and computers, that is, product/market positions that had already undergone a shift to digital technology. Firms in those industries may already possess relevant capabilities, such as processes for new product development, distribution, or manufacturing. Indeed, the distribution channels used by consumer electronics and computer firms were likely to be more important for distributing digital cameras than were existing film channels, such as drugstores or grocery stores (Gerard, 1997).

Process management practices have been shown to increase efficiency and speed in existing capabilities. To the extent the capabilities of entrants are appropriate for a digital environment, process management practices applied to those capabilities will spur even greater responsiveness to the unfolding technological change to digital photography.

H2: Increasing, process management activities within nonincumbent entrants will be associated with greater responsiveness to digital technology through new products.

Methods

Sample

The study draws on a sample of firms that entered the digital camera market in the 1990s, during the rapid change as digital technology increasingly substituted for the traditional photography technologies. Although firms could respond to digital technology in a variety of ways (e.g., by introducing scanners, software, printers), entry into the digital camera market was a consistent response among film and camera incumbents and other entering firms. Thus, the number and timing of digital camera product introductions allows for comparing responsiveness across firms that entered over time.

The study focuses on the time frame following the introduction of the Apple QuickTake camera for the consumer market in 1994, as this is the event that triggered rapid technological change and the increasing certainty of technological substitution. Studying ongoing responsiveness to the unfolding change required identifying the firms that both entered the (under $1,000) consumer camera segment of the market and that continued to participate by introducing cameras in subsequent generations of digital camera technology. Assessing the factors that affect response over time requires identifying firms that continued to respond through at least two generations of digital technology. Entrants into the digital camera market were identified from issues of the *Future Image Report*, an industry newsletter published by Future Image, Inc., 10 times a year since 1993. Since the study's focus is on ongoing responsiveness to rapid technological change in digital cameras for the consumer market (under $1,000), these firms were deleted from the data set. Another 25 firms introduced cameras in the consumer market but introduced only one digital camera during the period. This set includes firms like Intel, 3Com, KB Gear, Mattel (which introduced a $64 Barbie camera), and Nintendo (which introduced a $49 Gameboy camera). These firms were also not included in the study. Thus, there were 37 firms that introduced more than one digital camera for the consumer market over the period. This list of firms was used to collect data to measure the other variables. Revenue or patent data were not available for some firms, resulting in a final sample of 19 firms.

A limitation of studying a sample of larger, public firms is the potential lack of generalizability of the results to smaller firms or start-ups. However, the sample includes nearly the universe of firms that both entered the digital camera market and continued to participate actively in the market through multiple generations of technological change. Thus, it is clear that such firms had at least some intent during the period to "keep up" with the technological changes, making a study of the factors that affect this ability interesting and relevant.

To test for differences in the effects of ISO 9000 on incumbents and nonincumbents, the set of 19 firms was further divided into incumbent firms (i.e., firms previously in film and analog photography technologies) including Agfa, Fuji Photo, Kodak, Leica, Minolta, Nikon, Olympus, and Polaroid, and other non-incumbent entrants including Canon, Casio, Epson, Hewlett-Packard, JVC, Konica, Matsushita, Philips, Ricoh, Sony, and Toshiba. Incumbent and nonincumbent entrants were distinguished using several sources, including an assessment of primary businesses provided by COMPUSTAT and Worldscope, lists of photography industry participants in years prior to the technological change from Moody's and Dun & Bradstreet, and an article by Simpson and Raman (1998) that categorized the firms entering the digital camera market and highlighted the likely challenges they would face.

Measures

Dependent Variables. A firm's *responsiveness* to the change to digital technology was measured as firms' introductions of digital camera products. Data were collected on all introductions of new digital cameras from 1991 to 2003 from the *Future Image Report*. In the panel models using count data, the dependent variable is measured as counts of new digital camera product introductions by firm/year. This measures a firm's ongoing response to the annual unfolding of technological change improved generations of camera resolution. Conceptualizing and measuring response as new product introductions is also consistent with prior research on rapid technological change (e.g., Brown and Eisenhardt, 1997; Eisenhardt and Tabrizi, 1995). In the hazard model, discussed in the next section, the dependent variable is a 1 in the year a firm introduced its first product in each subsequent technological generation (e.g., one-megapixel, two-megapixel).

Independent Variable. Following previous research (Benner and Tushman, 2002), increased attention to *process management practices* was measured with data on ISO 9000 quality program certifications. The ISO 9000 certification data are particularly appropriate for measuring organizational routinization. To receive an ISO 9000 certification, an approved registrar (e.g., Underwriters' Laboratories; UL) ensures that the processes under consideration for certification have been documented. In addition, registrars subsequently conduct random, periodic audits to verify that certified firms are carrying out organizational activities following these codified processes. The monitoring by approved registrars indicates that the practices required for certification are followed and increases the likelihood that such practices are similar for multiple certifications within a firm as well as across firms and over time. In addition, monitoring prevents organizations' gaining benefits of certification without undertaking the process-focused practices, a possibility raised in prior research (cf. Westphal, Gulati, and Shortell, 1997; Zbaracki, 1998). ISO 9000 certifications are thus received by organizations that adhere to processes that are mapped and are repeatable. As mentioned earlier, a greater number of ISO 9000 certifications in a firm over time are assumed to reflect more extensive activities focused on routinization.

Data on ISO 9000 certifications were obtained from McGraw Hill, which provides a database of certifications collected directly from the third-party ISO 9000 registrars. This source of data overcomes many of the weaknesses of studies relying on subjective self-reports of adopting firms (cf. Easton and Jarrell, 1998). Data were cross-checked with similar ISO 9000 data available from the Quality Digest website to ensure full coverage of firms. Measures of process management practices were constructed as the cumulative count of ISO 9000 certifications for each company by year, from the start of the ISO 9000 program in 1991 (for the earliest adopters in this industry) through the decade until 2000. Thus, for example, the number of ISO 9000 certifications for a firm in 1996 is the sum of the certifications through 1995 plus the new certifications for 1996. This approach takes full advantage of the available data, as it captures the new certifications each year as well as the "stock" of existing certifications, which continues to influence the extent of organizational adherence to repeatable processes. As described in more detail in the models section, longitudinal panel models with fixed-effects and year controls consider the "within-firm" variation; that is, they model how year-to-year changes in the independent variable (a firm's new ISO 9000 certifications) affect changes in the dependent variable (annual counts of new digital cameras) while also controlling for the cumulative "stocks" of prior certifications.

The ISO 9000 certification includes a written scope section, outlining the activities covered by the certification. These texts were not reliable enough for systematic use in the study, but they enabled a check of whether certification activities generally pertained to capabilities that existed prior to digital technology, especially important for understanding the effects on incumbent firms. Both the standard industrial classification (SIC) codes and scope data suggest that the ISO 9000 practices measures captures the extent of activities focused on operating processes that existed prior to the technological change.

Interaction Variables. The dummy variable, *incumbent*, is coded 1 for the eight incumbent firms previously listed. An interaction variable (incumbent × ISO 9000 practices) allows for isolating the effect of ISO 9000 practices on incumbents and therefore captures any differences in results for incumbents and other entrants. Including the interaction term essentially divides the sample, with the coefficient on the interaction variable indicating whether increasing ISO 9000 certifications have different effects on response for the incumbent firms and other firms. This approach has the advantage that it retains the full set of data in one model.

Control Variables. Patents are measured as a count of patents or inventions for each firm in the patent classes related to photography and imaging shown in Table 1. Patents control for each firm's general attention to technological innovation, which could separately facilitate response to the technological change in photography. Patent data are coded according to the year of patent application, which allows for measuring the innovation activity close to the time it was undertaken (Ahuja, 2000). A two-year rolling average of patents is included in the models. Annual *revenue* data from COMPUSTAT (for U.S. firms) and Worldscope (for non-U.S. firms) control for firm size or, alternatively, in the fixed effects models, control for changes in resources within firms, over time.

Models

The hypotheses are tested using both longitudinal panel data models with new product counts (controlling for firm fixed effects and years) and a multiple-event hazard model. These two models allow for related but distinct measures of responsiveness—ongoing new product introductions required to respond to rapid change, in addition to a firm's speed of introduction of each new digital camera generation.

Longitudinal panel data models with fixed-effects controls rely on within-firm variation; that is, they assess how the pattern of increasing ISO 9000 practices *within* a particular firm over the time frame statistically relates to that firm's pattern of new digital camera products. The advantage of using fixed-effects controls with panel data is that they provide an "ability to control for all stable covariates, without actually including them in a regression equation" (Allison and Waterman, 2002, p. 247). This design helps mitigate the risk of alternative explanations and omitted variable bias if three types of factors are controlled

Table 1. Patent Classification Codes: Photography and Imaging

Patent Class	Title
250	Radiant Energy
345	Computer Graphics Processing, Operator Interface Processing, and Selective Visual Display Systems
348	Television (many digital camera patents are included here)
355	Photocopying
356	Optics: Measuring and Testing
359	Optics: Systems (Including Communication) and Elements
360	Dynamic Magnetic Information Storage or Retrieval
382	Image Analysis
386	Television Signal Processing for Dynamic Recording or Reproducing
396	Photography
428	Stock Material or Miscellaneous Articles
430	Radiation Imagery Chemistry: Process, Composition, or Product Thereof

(Hsiao, 1986, p. 25): (1) factors that vary over time within firms, such as research and development (R&D) expenditures or financial performance; (2) factors that vary over time but affect all firms in the sample, such as general industry conditions; and (3) factors that are stable within a firm over time but vary across firms, such as organizational culture or management know-how or, in this case, firms' tendencies to introduce broader or narrower product lines with each technology generation. Here, the first type of omitted variable is controlled with measures of both revenue and patents that capture changes in firm resources over time. Year dummy variables are used to control for the factors that vary over time and affect all firms, such as overall increases in the number of firms in the market, the increasing introductions of digital cameras, or increases in ISO 9000 practices over the period. 1994 is the base year.

Since the dependent variable in the panel data model is product count data, a Poisson or negative binomial model specification is required. A comparison of the mean and variance (mean = 1.1; standard deviation = 2.4) suggests evidence of overdispersion, making the negative binomial specification the most appropriate choice (Cameron and Trivedi, 1990; Guo, 1996; King, 1988). The models were run in STATA using firm dummy variables to control for firm fixed effects. The results were similar using the Poisson specification or the negative binomial specification.

The panel data negative binomial models run from 1994 to 2002 and include either a one-year or two-year lag on the ISO 9000 practices variable. This accounts for the time required for ISO 9000 certification practices to affect firms' subsequent new product developments. Since ISO 9000 certification focuses on ongoing adherence to documented processes, the influence of prior ISO 9000 certifications on organizational routinization continues even as new certifications are added.

The second model is a multiple event Cox proportional hazard model. The dependent variable is the timing of entry into each digital resolution generation. In a Cox model, the hazard rate includes an unspecified baseline rate, $h(t)$, and a term specifying the effect of a set of covariates on the underlying hazard. Using a Cox model is consistent with prior research that considers the effect of covariates on the hazard of events (e.g., Rao, Greve and Davis, 2001; Sorenson and Stuart, 2000). The model is run using *xtcox* in STATA and includes robust standard errors by clustering at the firm level. Spells are annual, and covariates include ISO 9000 certifications, revenue, and patents. A measure of the cumulative sum of patents is used in the hazard model, following Sorenson and Stuart. Hazard model results were identical with either the rolling average or cumulative sum patent measures.

Results

Summary statistics are shown in Table 2 for the sample of 19 firms. In all, the firms in the sample introduced 456 digital cameras between 1994 and 2003. Incumbent firms introduced an average of 36 digital cameras, whereas the nonincumbent entrants introduced an average of 20 cameras. Incumbents had an average of 16 ISO 9000 certifications, whereas nonincumbent firms had an average of 21 ISO 9000 certifications.

Table 3 shows the results of the panel negative binomial models of the effect of increasing ISO 9000 certifications by firm over time on subsequent annual counts of new digital camera product introductions. These models incorporate firm fixed effects in addition to year dummy controls. Coefficients on the year dummy controls were positive and significant in all the models, reflecting the overall higher levels of digital camera introductions in each year over the base year, 1994. Model 2 in Table 3 includes the main effect of ISO 9000 certification practices with a one-year lag, whereas Model 4 shows the ISO 9000 variable with a two-year lag. The coefficient on the ISO 9000 variable

Table 2. Summary Statistics

	Average	Standard Deviation	Min	Max
Cumulative ISO 9000 Certifications by Firm	19	28.8	0	99
For Incumbents	16	23	0	63
For Nonincumbents	21	32	0	99
Digital Camera Product Introductions by Firm	24	21	4	73
For Incumbents	36	24	5	73
For Nonincumbents	20	17	4	68
Annual Patents	147	167	1	998
Firms' Annual Revenue (in Millions $US)	17852	19431	130	71187

is negative and significant in both models (at $<.05$), suggesting that increasing practices associated with ISO 9000 certifications had a negative effect subsequent response to the ongoing technology change. The interaction term (incumbent × ISO 9000 practices) is included in Models 3 and 5, for the one-year and two-year lagged ISO 9000 variable, respectively. The coefficient on the interaction term (which isolates the incumbent firms and tests whether the effects of increasing ISO 9000 practices differs for incumbents relative to the nonincumbent entrants) is negative and strongly significant (at $<.01$) in both models.

These results show that ISO 9000 practices dampened response for all the firms in the sample but that the negative effect is more strongly negative for the incumbent firms' responsiveness. Note that the ISO 9000 practices variable, the incumbent dummy variable, and the interaction term were all entered into the models. The main effect of the incumbent variable is dropped in the results of a panel data model with fixed effects, since incumbency is a stable characteristic that does not vary over time (i.e., it is already included in the fixed effect.) The significance of the main effect disappears in the models with the interaction terms, suggesting that the negative effect of ISO 9000 practices is largely due to the effect on incumbents. These findings suggest support for the argument that process management practices will hamper responsiveness for incumbents and that their effects will be more detrimental for incumbents than for nonincumbents. However, although the effect of ISO 9000 practices on nonincumbent firms is less negative than for incumbents, there is not a clear positive effect on response for the nonincumbents.

By excluding the revenue variable, it was possible to run the models on a larger set of 22 firms. The results are not included here for space considerations but show identical signs and significance on the coefficient of the interaction term, again supporting the main finding that the effects of ISO 9000 on responsiveness are negative and, further, are more negative than for nonincumbents. In these models, however, without the control for size, the main effect of the ISO 9000 practices variable is not significant.

Table 3. Effect of ISO 9000 Certification Practices on Counts of Digital Camera Product Introductions[a]

	Model 1	Model 2	Model 3	Model 4	Model 5
Patents	0.0002	0.0001	– 0.00001	0.0004	0.0003
	(0.0006)	(0.0008)	(0.0008)	(0.0006)	(0.0006)
Revenue	0.0338**	0.0764***	0.0430	0.0660***	0.0254
	(0.0166)	(0.0234)	(0.0264)	(0.0197)	(0.0226)
ISO 9000 Practices $_{t-1}$		– 0.0286**	– 0.0162		
		(0.0136)	(0.0157)		
Incumbent × ISO9000 Practices $_{t-1}$			– 0.0916***		
			(0.0300)		
ISO 9000 Practices $_{t-2}$				– 0.0274***	– 0.0108
				(0.0098)	(0.0114)
Incumbent × ISO 9000 Practices $_{t-2}$					– 0.0723***
					(0.0184)
Year Dummy Controls	yes	yes	yes	yes	yes
Firm Fixed Effects	yes	yes	yes	yes	yes
Constant	– 1.879***	– 0.739	– 4.188***	– 1.269**	– 4.263***
	(0.5387)	(0.6386)	(1.1311)	(0.5681)	(0.9456)
Observations	158	142	142	158	158
Firms	19	19	19	19	19

[a] Cross-sectional time series (panel) negative binomial models. Models include firm fixed effects and year controls. Standard errors in parentheses.
* $p<.1$.
** $p<.05$.
*** $p<.01$.

Finally, the results of the multiple event hazard models are shown in Table 4. As shown in Model 2, the main effect of ISO 9000 practices variable on response to technological change is not significant. Model 4 introduces the interaction term (incumbent × ISO 9000 practices). Similar to the results from the panel model specifications in Table 3, the coefficient on the interaction term is negative and significant (at $<.05$), indicating that greater process management activities associated with ISO 9000 had a more negative effect on responsiveness of incumbents than other nonincumbent entrants. Since this model does not control for fixed effects, the coefficient on the incumbent dummy variable remains. This also shows that there is not a significant main effect of incumbency on response. That is, incumbents did not generally respond faster or slower to subsequent generations of digital cameras, but to the extent they adopted ISO 9000 practices, their response was slower. These alternative models show that the results are robust to different conceptualizations and measures of responsiveness. Again, as in the panel data models, excluding the revenue variable allowed for testing the hypotheses on a larger sample of firms. The results are similar with the larger sample.

Discussion

The study findings suggest that the increasing process management practices associated with ISO 9000 certifications were more harmful for the responsiveness of incumbent firms with capabilities in the old technology than for the nonincumbent firms entering the digital camera market from other industries. These findings are robust to different measures and specifications. This suggests further that the extent to which process management activities help or hinder adaptation depends on differences in firms' prechange configurations of capabilities and the magnitude of change required in those capabilities to make them appropriate in a new technology. Further, these results using panel data models with fixed effects indicate that effects on responsiveness are attributable to firm-specific patterns of increases in ISO 9000 practices, not to differences across firms.

Table 4. Hazard Model (Multiple Event): Effect of Covariates on the Repeated Hazard of Entry into Each New Generation of Digital Camera Products[a]

	Model 1	Model 2	Model 3	Model 4
Patents	0.0175***	0.0229***	0.0223***	0.0248***
	(0.0031)	(0.0043)	(0.0036)	(0.0047)
Revenue	− 0.0009	− 0.0005	0.0036	0.0007
	(0.0035)	(0.0036)	(0.0072)	(0.0072)
ISO 9000		− 0.0007	− 0.0014	0.0030
Practices		(0.0026)	(0.0026)	(0.0025)
Incumbent			0.2366	0.3939
			(0.3029)	(0.3580)
Incumbent ×				− 0.0139**
ISO 9000				(0.0056)
Log-Likelihood	− 338.32	− 268.62	− 268.29	− 267.5
Firms	19	19	19	19
Events	75	75	75	75

[a] Robust standard errors in parentheses.
†$p<.1$; **$p<.05$; ***$p<.01$.

This work contributes to research on how organizational routines influence firm adaptation to a major environmental change. It suggests that codification and routinization are not dynamic capabilities, and whether such activities spur adaptation in an organization depends on the extent of change in capabilities required for the changed environment. In addition, this work contributes to literature on process management practices. Recent work to understand the influence of these ubiquitous practices in organizations has begun to evaluate the effects of such practices on longer-term implications for firms and outcomes like learning and innovation (e.g., Benner and Tushman, 2002; Repenning and Sterman, 2002; Sitkin et al., 1994). This work extends these ideas to new product development required for response or adaptation to rapid technological change. The finding that process management's effects on responsiveness and adaptation may be moderated by firms' prior sets of capabilities and are more disadvantageous for incumbents faced with a major technological change furthers our understanding of how these practices affect organizations. These findings also contribute to research on the challenge of technological change for incumbent firms, by identifying specific, observable management practices that may constrain firms' responses to technological change.

This work also contributes to research on dynamic capabilities. Process management practices are pervasive metapractices to routinize the underlying processes in organizations; as such, studying their effects on organizations provides an empirical opportunity to better understand the relationship between dynamic capabilities (as defined ex ante) and organizational outcomes ex post. Process management practices provide an instance of patterned, collective activities systematically focused on improving operating processes and routines, a common definition of a dynamic capability (e.g., Zollo and Winter, 2002). Similarly, these practices have also been promoted to managers as a vehicle for organizational transformation and change (e.g., Hammer and Stanton, 1999; Kolesar, 1993; Pande et al., 2000). Process management practices may improve existing capabilities and spur faster response to rapid change within an existing technological regime but may slow response when more dramatic capability transformation or replacement is required (cf. Abernathy and Utterback, 1978; Lavie, 2006).

This study further highlights an opportunity to study the effects of pervasive programs in management practice that affect capabilities and dynamic capabilities. Studies of how organizations could or should develop dynamic capabilities rarely take into account the effects of externally mandated practices that are adopted in similar ways across organizations. Over the past two decades, managers have been pressured to adopt programs like TQM, ISO 9000, or Six Sigma. While interest in programs like ISO 9000 may have waned in recent years, Enterprise Resource Planning (ERP) systems (e.g., SAP) have gained popularity, driven by similar institutional pressures as customers and consultants promote the promise of efficiency benefits and improved organizational effectiveness in meeting customer needs. This echoes the impetus behind earlier versions of process management like TQM and the Malcolm Baldrige Award Criteria. Moreover, ERP systems include standardized ''best practices'' for many business functions and information systems for collecting and tracking information through streamlined, linked activities (e.g., Gargeya and Brady, 2005). It is likely that ERP systems increase routinization and affect the flexibility of organizational processes. Research could benefit from studying how these practices influence change in capabilities and longer-term adaptation and survival in the face of environmental change.

Finally, this work also contributes to management practice. Institutional pressures have been strong for organizations to adopt process management techniques such as ISO 9000 or Six Sigma regardless of their organizational or environmental contexts (e.g., Guler, Guillen, and MacPherson, 2002; Heaphy and Gruska, 1995; ISO, 2006; Westphal et al., 1997). As high uncertainty triggers an increase in the institutional pressures toward coercive, mimetic, and normative isomorphism (DiMaggio and Powell, 1983), the pressure to focus efforts on organizational processes may be particularly strong during periods of uncertain technological change. Incumbent firms facing a radical technological change may face the strongest pressure to adopt process management practices to improve the competitiveness, efficiency, and effectiveness of an old technology precisely at the time when they most need to transform capabilities. Managers in firms facing dramatic environmental change should apply such techniques selectively to avoid dampening the responsiveness critical for longer-term survival.

References

Aaland, M. (1993). Portable Digital Cameras. *Future Image Report* 1(6):4–5. Future Image Inc., San Mateo, CA. Available for purchase online at: http://futureimagestore.com/component/option,com_virtuemart/page,shop.browse/category_id,4/Itemid,29/.

Abernathy, W.J. (1978). *The Productivity Dilemma*. Baltimore: Johns Hopkins University Press.

Abernathy, W.J. and Utterback, J.M. (1978). Patterns of Industrial Innovation. *Technology Review* 80:40–47.

Adler, P.S. (1993). Time-and-Motion Regained. *Harvard Business Review* 71(1):97–108.

Ahuja, G. (2000). Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. *Administrative Science Quarterly* 45:425–55.

Allison, P.D. and Waterman, R. (2002). Fixed Effects Negative Binomial Regression Models. In: *Sociological Methodology*, ed. R. Stolzenbert. Boston: Basil Blackwell, 247–65.

Anderson, J.C., Rungtusanatham, M., and Schroeder, R.G. (1994). A Theory of Quality Management Underlying the Deming Management Method. *Academy of Management Review* 19:473–509.

Anderson, P. and Tushman, M.L. (1990). Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change. *Administrative Science Quarterly* 35:604–33.

Austen, I. (2002). Tapping into Its Strengths, the Empire of Film Strikes Back. *New York Times*, May 23, Section G, p. 8.

Benner, M.J. and 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.J. and Tushman, M.L. (2003). Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited. *Academy of Management Review* 28:238–56.

Benner, M.J. and Veloso, F.M. (2008). ISO 9000 Practices and Financial Performance: A Technology Coherence Perspective. *Journal of Operations Management* 26:611–29.

Brown, S.L. and Eisenhardt, K.M. (1997). The Art of Continuous Change: Linking Complexity Theory and Time-Paced Evolution in Relentlessly Shifting Organizations. *Administrative Science Quarterly* 42:1–34.

Cameron, C. and Trivedi, P.K. (1990). Regression-Based Tests for Overdispersion in the Poisson Model. *Journal of Econometrics* 46:347–64.

Cameron, K. and Barnett, C. (2000). Organizational Quality as a Cultural Variable. In: *The Quality Movement and Organization Theory*, ed. R.E. Cole and W.R. Scott. Thousand Oaks, CA: Sage.

Christensen, C.M. and Bower, J.L. (1996). Customer Power, Strategic Investment, and the Failure of Leading Firms. *Strategic Management Journal* 17:197–218.

Cohen, W.M. and Levinthal, D.A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly* 35:128–52.

Cole, R.E. (1998). Learning from the Quality Movement: What Did and Didn't Happen and Why? *California Management Review* 41(1):43–73.

Cole, R.E. and Scott, W.R. (2000). *Introduction. The Quality Movement & Organization Theory*. Thousand Oaks, CA: Sage Publications.

Cooper, A. and Smith, C. (1992). How Established Firms Respond to Threatening Technologies. *Academy of Management Executive* 6(2):55–70.

Corbett, C., Montes-Sancho, M., and Kirsch, D. (2005). The Financial Impact of ISO 9000 Certification in the U.S.: An Empirical Analysis. *Management Science* 51:1046–59.

Dahlin, K.B. and Behrens, D.M. (2005). When Is an Invention Really Radical? Defining and Measuring Technological Radicalness. *Research Policy* 35:717–34.

Dean, J.W. Jr. and Bowen, D.E. (1994). Management Theory and Total Quality: Improving Research and Practice through Theory Development. *Academy of Management Review* 19:392–418.

DiMaggio, P.J. and Powell, W.W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review* 48:147–60.

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

Easton, G.S. and Jarrell, S.L. (1998). The Effects of Total Quality Management on Corporate Performance: An Empirical Investigation. *Journal of Business* 71:253–307.

Eisenhardt, K. and Martin, J. (2000). Dynamic Capabilities: What Are They? *Strategic Management Journal* 21:1105–21.

Eisenhardt, K. and Tabrizi, B.N. (1995). Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry. *Administrative Science Quarterly* 40:84–110.

Future Image Report. (1997). Vol. 5, Issue 4. San Mateo, CA: Future Image Inc.

Gargeya, V.B. and Brady, C. (2005). Success and Failure Factors of Adopting SAP in ERP System Installation. *Business Process Management Journal* 11:501–17.

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.

Gatignon, H., Tushman, M., Smith, W., and Anderson, P. (2002). A Structural Approach to Assessing Innovation. *Management Science* 48:1103–22.

Gerard, A. (1997). Research: The Action Shifts to Photo Quality. Channel Breakdown. *Future Image Report* 5(4):5. Available for purchase online at: http://futureimagestore.com/component/option,com_virtuemart/page,shop.browse/category_id,4/Itemid,29/.

Glasmeier, A. (1991). Technological Discontinuities and Flexible Production Networks: The Case of Switzerland and the World Watch Industry. *Research Policy* 20:469–85.

Guler, I., Guillen, M.F., and MacPherson, J.M. (2002). Global Competition, Institutions and the Diffusion of Organizational Practices: The International Spread of ISO 9000 Quality Certificates. *Administrative Science Quarterly* 47:207–32.

Guo, G. (1996). Negative Multinomial Regression Models for Clustered Event Counts. In: *Sociological Methodology* (vol. 26), ed. A.E. Raftery. San Francisco: John Wiley, 113–132.

Hackman, J.R. and Wageman, R. (1995). Total Quality Management: Empirical, Conceptual, and Practical Issues. *Administrative Science Quarterly* 40:309–42.

Hammer, M. and Champy, J. (1993). *Reengineering the Corporation: A Manifesto for Business Revolution*. New York: Harper Business.

Hammer, M. and Stanton, S. (1999). How Process Enterprises Really Work. *Harvard Business Review* 77(6):108–18.

Hannan, M.T. and Freeman, J. (1984). Structural Inertia and Organizational Change. *American Sociological Review* 49:149–64.

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

Hausman, J., Hall, B., and Griliches, Z. (1984). Econometric Models for Count Data with an Application to the Patents–R&D Relationship. *Econometrica* 52:909–38.

Heaphy, M.S. and Gruska, G.F. (1995). *The Malcolm Baldrige National Quality Award*. Boston: Addison-Wesley.

Helfat, C.E. (2000). Guest Editor's Introduction to the Special Issue: The Evolution of Firm Capabilities. *Strategic Management Journal* 21:955–59.

Helfat, C.E. and Lieberman, M.B. (2002). The Birth of Capabilities: Market Entry and the Importance of Pre-history. *Industrial and Corporate Change* 11:725–60.

Henderson, R. (1993). Underinvestment and Incompetence as Responses to Radical Innovation: Evidence from the Photolithographic Equipment Industry. *Rand Journal of Economics* 24(2):248–70.

Henderson, R.M. and Clark, K.B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly* 35:9–30.

Hendricks, K.B. and Singhal, V.R. (1996). Quality Awards and the Market Value of the Firm: An Empirical Investigation. *Management Science* 42:415–36.

Hill, C.W.L. and Rothaermel, F.T. (2003). The Performance of Incumbent Firms in the Face of Radical Technological Innovation. *Academy of Management Review* 28:257–74.

Hsiao, C. (1986). *Analysis of Panel Data*. Cambridge, UK: Cambridge University Press.

International Organization for Standardization (ISO). (2006). The Magical Demystifying Tour of ISO 9000 and ISO 14000. Available at: http://www.iso.org/iso/about.htm.

Ittner, C.D. and Larcker, D. (1997). The Performance Effects of Process Management Techniques. *Management Science* 43:522–34.

King, G. (1988). Statistical Models for Political Science Event Counts: Bias in Conventional Procedures and Evidence for the Exponential Poisson Regression Model. *American Journal of Political Science* 32:838–63.

Kolesar, P.J. (1993). Vision Values Milestones: Paul O'Neill Starts Total Quality at Alcoa. *California Management Review* 35(3):133–65.

Landes, D. (1983). *Revolution in Time: Clocks and the Making of the Modern World*. Boston: Harvard University Press.

Lavie, D. (2006). Capability Reconfiguration: An Analysis of Incumbent Responses to Technological Change. *Academy of Management Review* 31(1):153–74.

Leonard-Barton, D. (1992). Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal* 13:111–25.

Levinthal, D. (1991). Organizational Adaptation and Environmental Selection—Interrelated Processes of Change. *Organization Science* XX:140–45.

Levinthal, D. (2000). Organizational Capabilities in Complex Worlds. In: *The Nature and Dynamics of Organizational Capabilities*, ed. G. Dosi, R. Nelson, and S. Winter. Oxford: Oxford University Press, 363–76.

Levinthal, D. and March, J.G. (1993). The Myopia of Learning. *Strategic Management Journal* 14:95–112.

Levitt, B. and March, J.G. (1988). Organizational Learning. *Annual Review of Sociology* 14:319–40.

March, J. (1991). Exploration and Exploitation in Organizational Learning. *Organization Science* 2:71–87.

Nelson, R. and Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Pande, P.S., Neuman, R.P., and Cavanagh, R.R. (2000). *The Six Sigma Way: How GE, Motorola, and Other Top Companies Are Honing Their Performance*. New York: McGraw-Hill.

Powell, T.C. (1995). Total Quality Management as Competitive Advantage: A Review and Empirical Study. *Strategic Management Journal* 16:15–37.

Quality Digest. (2009). Database of ISO 9000-Certified Companies. Available at: http://www.qualitydigest.com/content/iso-database.

Rao, H., Greve, H.R., and Davis, G.F. (2001). Fool's Gold: Social Proof in the Initiation and Abandonment of Coverage by Wall Street Analysts. *Administrative Science Quarterly* 46:502–26.

Repenning, N.P. and Sterman, J.D. (2002). Capability Traps and Self-Confirming Attribution Errors in the Dynamics of Process Improvement. *Administrative Science Quarterly* 47:265–95.

Rosenbloom, R.S. (2000). Leadership, Capabilities, and Technological Change: The Transformation of NCR in the Electronic Era. *Strategic Management Journal* 21:1083–1103.

Samson, D. and Terziovski, M. (1999). The Relationship between Total Quality Management Practices and Operational Performance. *Journal of Operations Management* 17:393–409.

Schumpeter, J. (1942). *Capitalism, Socialism, and Democracy*. New York: Harper.

Simpson, L. and Raman, R. (1998). Digital Cameras. *Future Image Report* 6(2):7. Available for purchase online at: http://futureimagestore.com/component/option,com_virtuemart/page,shop.browse/category_id,4/ltemid,29/.

Singh, H. and Montgomery, C. (1987). Corporate Acquisition Strategies and Economic Performance. *Strategic Management Journal* 8(4):377–86.

Shippey, F. (1993). Business News—PMA Report. *Future Image Report* 1(1):2–3. Available for purchase online at: http://futureimagestore.com/component/option,com_virtuemart/page,shop.browse/category_id,4/ltemid,29/.

Sitkin, S.B., Sutcliffe, K.M., and Schroeder, R.G. (1994). Distinguishing Control from Learning in Total Quality Management: A Contingency Perspective. *Academy of Management Review* 19:537–64.

Sorenson, J. and Stuart, T.E. (2000). Aging, Obsolescence, and Organizational Innovation. *Administrative Science Quarterly* 45:81–112.

Sterman, J.D., Repenning, N.P., and Kofman, F. (1997). Unanticipated Side Effects of Successful Quality Programs: Exploring a Paradox of Organizational Improvement. *Management Science* 43:503–21.

Suarez, F. and Utterback, J. (1995). Dominant Designs and the Survival of Firms. *Strategic Management Journal* 16:415–30.

Sutcliffe, K., Sitkin, S., and Browning, L. (2000). Tailoring Process Management to Situational Requirements. In: *The Quality Movement & Organization Theory*, ed. R. Cole and W. Scott. London: Sage, 315–30.

Teece, D.J., Pisano, G., and Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal* 18:509–33.

Tripsas, M. (1997). Surviving Radical Technological Change through Dynamic Capability: Evidence from the Typesetter Industry. *Industrial and Corporate Change* 6(2):341–77.

Tripsas, M. and Gavetti, G. (2000). Capabilities, Cognition, and Inertia: Evidence from Digital Imaging. *Strategic Management Journal* 21:1147–61.

Tushman, M.L. and Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly* 31:439–65.

Tushman, M. and Nelson, R. (1990). Technology, Organizations and Innovation: An Introduction. *Administrative Science Quarterly* 35:1–8.

Tushman, M.L. and Romanelli, E. (1985). Organizational Evolution: A Metamorphosis Model of Convergence and Reorientation. In: *Research in Organizational Behavior* (vol. 7), ed. L.L. Cummings and B.M. Staw. Greenwich, CT: JAI Press, 171–222.

Utterback, J. (1994). *Mastering the Dynamics of Innovation*. Boston: Harvard Business School Press.

Uzumeri, M. (1997). ISO 9000 and Other Metastandards: Principles for Management Practice? *Academy of Management Executive* 11:21–37.

Westphal, J.D., Gulati, R., and Shortell, S.M. (1997). Customization or Conformity? An Institutional and Network Perspective on the Content and Consequences of TQM Adoption. *Administrative Science Quarterly* 42:366–94.

Winter, S. (2000). Organizing for Continuous Improvement: Evolutionary Theory Meets the Quality Revolution. In: *The Quality Movement & Organization Theory*, ed. R. Cole and W. Scott. London: Sage, 49–64.

Winter, S. (2003). Understanding Dynamic Capabilities. *Strategic Management Journal* 24:991–95.

Wruck, K. and Jensen, M. (1994). Science, Specific Knowledge, and Total Quality Management. *Journal of Accounting and Economics* 18:247–87.

Zbaracki, M.J. (1998). The Rhetoric and Reality of Total Quality Management. *Administrative Science Quarterly* 43:602–36.

Zollo, M. and Winter, S. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. *Organization Science* 13:339–53.