

**PROCESS MANAGEMENT AND ORGANIZATIONAL ADAPTATION TO
TECHNOLOGICAL CHANGE: EVIDENCE FROM A SIMULATION
STUDY**

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ABSTRACT

This paper examines the role of process management techniques in organizational adaptation to changing technology. I propose that process management's focus on identifying, continuously improving, and adhering to organizational processes is likely to channel innovation into incremental forms that increase efficiency and performance in periods of incremental technological change. However, these incremental forms of innovation may also reduce more exploratory innovative activity and increase inertia, impeding an organization's ability to respond appropriately to more radical technological change. I test these hypotheses with preliminary data from an experimental study. I find evidence that process management has the potential to slow organizational response to technological change, but find no evidence for efficiency benefits in stable environments. This paper provides a first step into the relatively unexplored topic of the effect of process management on organizational or technological adaptation, while also shedding light on the conflicting results of research on process management and performance.

Whether and how quickly organizations can respond to technological change has critical implications for their performance and survival. Research has documented the consequences for organizations that fail to respond or respond inappropriately to technological change (Christensen & Bower, 1996; Henderson & Clark, 1990; Tushman & O'Reilly, 1997).

Differences in adaptive ability have been attributed both to the technological competences that result from innovation (Brown & Eisenhardt, 1997; Burgelman, 1983; Henderson & Clark, 1990; Tushman & Anderson, 1990), and to organizational inertia or resistance to change that arises from organizational tendencies to persist in past behaviors (Hannan & Freeman, 1984; Nelson & Winter, 1982).

While researchers attribute some of the differences in adaptive ability to factors within organizations, such as innovation, organizational research has not yet considered the role of a widely-used organizational practice—*process management*—in adaptation to technological change. Process management has been increasingly adopted in the last decade, often as part of programs such as Total Quality Management, the International Organization for Standards Series 9000 program (ISO 9000), the Malcolm Baldrige National Quality Award, and Business Process Reengineering. Research on process management has focused mainly on the effects of process management techniques on organizational performance, with equivocal results. While in some cases, the use of process management techniques has been associated with the expected benefits of increased efficiency or improved quality (Dean & Snell 1996; Ittner & Larcker, 1997; Sterman, Repenning & Kofman, 1997), these techniques have also been associated with decreased performance (Ittner & Larcker, 1997; Sterman, Repenning & Kofman, 1997), or no performance effects (Powell, 1995). The conflicting results underscore the need for additional theory and research to better understand the effects of these programs on organizations (Dean &

Bowen, 1994). This paper offers a possible alternative explanation for differential effects of process management. Theory and research on technological change and adaptation reveals the potential for process management to influence organizational response to technology change. The effects of process management may therefore depend on technological change in the environment. I also discuss the results of an experimental study designed to empirically explore the relationship between process management and adaptation to technology change.

This paper is part of a broader research program I am undertaking to explore the relationship between process management and organizational adaptation. Its purpose is to advance the understanding of factors that affect technological adaptation, in addition to further untangling the effects of process management on organizations. The paper proceeds in three main sections. First, I review organization theory and research in adaptation, innovation, and learning to develop a conceptual argument for process management's role in organizational adaptation to technological change. I argue that process management influences an organization's adaptability through its effects on both innovation and inertia. In the second section, I describe the preliminary findings from an experimental study that partially support the hypotheses developed in the first section. I conclude with a summary of the implications and limitations of this research.

THEORY AND HYPOTHESES

Technological Change in Organizational Environments

An important source of environmental change that challenges the adaptive capabilities of organizations is industry technology (Tushman & Anderson, 1986). Research has shown that technology evolves through cycles, alternating between periods of stability, following the emergence of a dominant technology design, and periods of rapid innovation and uncertainty

following the introduction of a new technology (Anderson & Tushman, 1990, Tushman & Rosenkopf, 1992). According to these views, once a dominant technology design emerges in an industry, technological change shifts from the period of rapid innovation to a focus on incremental improvement of the chosen technology (Tushman & Anderson, 1986). Successful adaptation during the incremental phase of a technology cycle is likely to depend on an organization's knowledge and ability to continually enhance the chosen technology. Thus, this period of relative technological stability is likely to favor the skills and capabilities of existing organizations who are already familiar with the dominant technology (Anderson & Tushman, 1990). Examples of dominant designs include VHS, selected over the earlier Betamax design for VCRs, or the Windows operating system, which became dominant over Apple or OS2 operating systems for personal computers (Tushman & O'Reilly, 1997). Once these technologies emerged as dominant designs, the focus of innovation has shifted to incremental improvements and cost reductions.

The technology cycle enters a period of rapid innovation following the introduction of a major technological advance (Anderson & Tushman, 1990). Such technological advances are often introduced by, and may favor, new entrants not wedded to the existing technology. During this period of innovation, successful organizational adaptation is likely to depend on more radical innovation within organizations that provides the appropriate options for responding to the technology change and its associated increase in uncertainty. This phase of the technology cycle ends with the emergence of a dominant technology design (Anderson & Tushman, 1990).

Particular types of innovations characterize each stage in a technology cycle. Researchers have categorized innovation by distinguishing between the core technologies in components within a product class, and the architectures, or linking mechanisms that combine

components into a system (Henderson & Clark, 1990). Innovation in an environment can then be characterized by how it affects existing organizational knowledge in component or architectural technologies.

Radical innovation is the simultaneous technological advance in both the components and linking mechanisms. Radical innovation tends to make obsolete the skills and capabilities of incumbent firms. At the other extreme, incremental innovation, characteristic of periods of incremental technological change, builds on the existing technical knowledge in both components and architectures. Henderson & Clark (1990) identify two additional forms of innovation between the extremes of radical and incremental innovation. Modular innovation creates change in the component technologies, while leaving the linking mechanism technology intact, while architectural innovation links components in new ways. These researchers focus on the potential for architectural innovation to create subtle challenges for established firms. They cite the experiences of organizations in the photolithographic alignment equipment industry who tended to perceive architectural innovation as incremental extensions of the current technology, and thus were unable to respond appropriately.

Thus, research suggests that technological change in organization environments evolves through cycles of incremental and radical change. Each stage of a technology cycle is characterized by different types of innovation, from incremental to radical, that create differential challenges for organizations.

Organizational Response to Technology Change—Innovation and Inertia

Adaptation to environments characterized by technological change requires the appropriate form of technological change within the organization. Research has explored the factors within organizations that influence adaptation to changing technology (e.g. Christensen

& Bower, 1996; Henderson & Clark, 1990; Tushman & O'Reilly, 1997). Here I focus on two factors that influence responsiveness to technology change: Innovation and inertia.

Innovative activity can affect adaptation by providing an organization with the technical competence and options to respond to environmental change (Brown & Eisenhardt, 1997; Burgelman, 1983; Tushman & O'Reilly, 1997). Innovation will be adaptive to the extent that it provides organizations with appropriate options to respond to the particular stage of technology in the environment. Organizational response to radical technology change requires technological innovations that depart radically from the existing technology (Tushman & O'Reilly, 1997). Conversely, successful response to an incrementally-changing environment requires rapid incremental innovation within a chosen dominant technology design (Tushman & Anderson, 1986). Thus, the nature of innovative activity carried out in the organization affects its ability to respond to the varying requirements of evolving technology.

Although incremental innovation may have benefits for organizations during stages of incremental innovation in the environment, it can have other effects on organizational adaptation through its effects on more exploratory activity. March (1991) discusses the difficulty in balancing activities focused on exploitation and exploration. The exploitation of current capabilities results in short term benefits, especially during incremental periods in technology cycles, while exploration, important for the long-term well-being of the firm, may have little measurable benefit in the short term. Thus, exploitative activities are likely to crowd out more exploratory activities. Incremental innovation exploits organizational knowledge and capabilities within an existing technology regime. Thus, in line with March (1991), it has the potential to restrict the search and learning of the organization, and reduce exploratory activity.

A preponderance of incremental innovation can further affect adaptation by limiting an organization's ability to recognize forms of innovation (Henderson & Clark, 1990). Organizations that perceive more radical innovations as incremental extensions of current capabilities are likely to respond inadequately. More exploratory forms of innovative activity within an organization may thus be required to perceive environmental technological change accurately. In addition, organizations focused primarily on incremental innovation may reduce their adaptive ability in yet another way. A lack of exploratory activity may preclude participation in subsequent rounds of technological development, by limiting an organization's absorptive capacity (Cohen & Levinthal, 1990), that is, the ability to understand and adopt a new technology.

Thus, innovation is one factor that plays an important role in organizational adaptation. The type and amount of innovation within an organization provides it with the "requisite variety," (Weick, 1969) or the breadth of options, to respond to changing technology (Brown & Eisenhardt, 1997; Burgelman, 1983). In addition, more exploratory innovation may allow organizations to accurately perceive technological change and respond with more than incremental extensions of the current technology.

The role of inertia, or resistance to change, has also been widely discussed in the change and adaptation literature (Hannan & Freeman, 1984; Tushman & Romanelli, 1985). Inertia arises from many sources, including investments in facilities or equipment, relationships with customers and suppliers (Hannan & Freeman, 1984), and the persistence of organizational activities that are increasingly carried out in stable routines and procedures (Cyert & March, 1963; Hannan & Freeman, 1984; March & Simon, 1958; Nelson & Winter, 1982). These routines are continually refined and streamlined through processes of first-order learning (Lant &

Mezias, 1992). As a result, the organization becomes more skilled and efficient at its current set of activities (Lant & Mezias, 1992), and organizational parts become increasingly coordinated and interdependent (Thompson, 1967). Although streamlined, efficient organizations are likely to do well in stable environments, researchers have argued that the persistence and increasing interdependence of organizational routines can render organizations slow or unable to respond to environmental change (Hannan & Freeman, 1984, Tushman & Romanelli, 1985, Gersick, 1991). Staw, Sandelands, and Dutton (1981) describe the “threat-rigidity” effect in which organizations respond to a need for change with an increase in the coordination and control of current activities, rather than the information search and consideration of alternatives.

Thus, an organization’s ability to recognize and adapt to technological change in the environment is influenced by both innovation and inertia. First-order learning and incremental innovation are likely to benefit organizations in responding to periods of incremental innovation in technology cycles. However, the focus on incremental innovation has the potential to impede organizational response in periods of more radical technological change, both by limiting the organization’s alternative responses, and by increasing inertia. Organizations engaged in more exploratory innovative activity are likely to have options for responding to more radical changes in technology.

Process Management

In the past several years, thousands of companies have adopted programs such as Total Quality Management, the International Organization for Standard’s 9000 Series Program (ISO 9000), the Malcolm Baldrige National Quality Program, and Business Process Reengineering. Though these programs differ in scope and approach, a central focus of each of these programs is organizational *process*; that is, on identifying processes and procedures that underlie business

activities (Hackman & Wageman, 1995; Hammer & Champy, 1993; Harrington & Mathers, 1997). I will argue that this core focus on organizational process influences both innovation and inertia, and therefore, adaptation to technological change.

Process management relies on an underlying view of organizations as “systems of interlinked processes.” (Dean & Bowen, 1994: 395). An organizational process is defined as “a set of activities that, taken together, produce a result of value to a customer” (Ittner & Larcker, 1997: 523). In the case of process management programs, this customer can be internal—other activities in the organization that use as inputs the outputs of prior organizational processes, or external, i.e. the consumer of the final product of the organization. A common example of an organizational process is a manufacturing assembly line, with discrete stages of assembly assigned to individuals and machines, and a specific product resulting at the end. Other examples of organizational processes (that may be implicit or explicit) are illustrated by new product developments that involve multiple stages of activity, such as engineering, manufacturing, and marketing; or, contract approvals that advance through multiple stages in an organizational hierarchy. Process management programs are not limited to processes such as manufacturing, that directly produce an output for an external customer, but can encompass any organizational processes or activities, including management decision processes such as the resource allocation processes described by Bower (1970).

Process management techniques typically begin with a phase of process mapping, that is, revealing and documenting the routines and procedures that underlie organizational activities (Garvin, 1995; Hackman & Wageman, 1995). The initial identification of processes is generally followed by continuous improvement efforts (Hackman & Wageman, 1995; Kolesar, 1993), with a focus on making processes “repeatable” and “in control” (Kolesar, 1993; Garvin, 1995). The

nature of this continuous improvement may vary somewhat depending on the particular form of process management adopted. For example, principles of Total Quality Management stress bringing processes into control by using statistical techniques to continually reduce any systematic statistical variation in the organization's processes, and to ensure that remaining variation is random (Hackman & Wageman, 1995). Other forms of process improvement involve re-engineering or changing processes to remove wasted steps that fail to contribute directly to value for internal or external customers (Garvin, 1995; Hammer & Champy, 1993). These programs often stress the importance of involving participants throughout the organization (Hackman & Wageman 1995; Hammer & Champy, 1993). As processes are continually improved, organizational participants are expected to adhere to the more streamlined, efficient activities.

Process Management and Technology Change

The potential effects of process management on technological adaptation can be viewed in light of the role of innovation and inertia discussed above. First, organizational processes can be seen as the underlying routines and procedures that guide organizational activities (Nelson & Winter, 1982). The explicit focus on repeating and continuously improving existing organizational capabilities (Garvin, 1995), can be seen as first-order learning, which, as discussed above, is likely to increase the coordination, interdependence, and efficiency of processes. Further, this focus on the improvement and refinement of existing capabilities is likely to affect the balance between exploitative and exploratory activity. As process management is explicitly focused on exploiting and extending current organizational capabilities, incremental forms of innovation are likely as an organization extends its current technological capabilities. During stages of incremental technological innovation in the

environment, this internal focus on incremental innovation is likely to contribute to successful adaptation.

Therefore, the combination of increased efficiency and incremental innovation is likely to result in performance benefits for organizations in periods of incremental change. Ittner & Larcker (1997) found performance benefits associated with process management techniques for firms in the automobile industry, but found process management was negatively associated with performance for firms in the computer industry. One possible explanation for these findings may lie in the differences in technological change between the two environments. The findings for the auto industry provide support for the beneficial role of process management in stable or incrementally-changing environments, contrasted with the results for the more rapidly-changing computer industry. Thus:

Hypothesis 1: Process management will be associated with performance benefits in environments characterized by incremental technological change.

However, there are disadvantages associated with the efficiency and continuous incremental improvement likely to result from process management techniques. The inertia that results from process management efforts to make current activities more streamlined and efficient also has the potential to slow organizational response to more radical change in the environment. In one documented case, measurable improvements in efficiency resulting from process management were followed by dramatic declines in performance as the organization lagged competitors in responding to an industry downturn (Serman, Repenning, & Kofman, 1997). In line with the arguments presented here, process management may have led to increases in organizational inertia which prevented the organization from responding rapidly to a sudden change in environmental conditions, in this case, a recession. In addition, to its effects on inertia, a concerted focus on exploiting existing capabilities is likely to affect innovative

activity by channeling it into more incremental forms. As a focus on incremental innovation has the potential to reduce more exploratory innovation (March, 1991), process management has the potential to accelerate this crowding-out of exploratory activity. A reduction in more radical innovation not only reduces the organization's options for responding to technological change, but also affects an organization's ability to recognize more radical technological developments (Henderson & Clark, 1990), and may preclude the acquisition and development of new technological capabilities (Cohen & Levinthal, 1990).

Thus, process management has the potential to slow organizational responsiveness to more radical technological change, both by increasing organizational inertia, and by channeling innovation into incremental forms.

Hypothesis 2: Process management will be negatively associated with the speed of change in response to technological change in the environment.

The effect of process management on organizational performance is thus likely to be influenced by both the nature of technological change in the environment, and the effects of process management on innovation and inertia within organizations. In the next section, I describe the design and preliminary results of an experimental study used to empirically test the hypotheses developed here.

METHOD

The effect of process management is difficult to study for several reasons. First, studying process management in organizations necessarily involves analyzing organizations that have already adopted process management techniques. A variety of organizational factors that lead to adoption might also lead to the observed outcomes of adoption. Although longitudinal designs can rectify this problem somewhat, the endogeneity of adoption complicates the interpretation of

the role of process management in organizational outcomes. A second challenge in studying process management arises from the difficulty of isolating process management techniques from other aspects of the programs that incorporate process management. For example, Total Quality Management (TQM) includes numerous practices in addition to a focus on process, such as benchmarking, techniques for meeting facilitation and brainstorming, and cross-functional teams. As my main interest in this research is process management, it is necessary to separate these techniques from the other elements of the above programs. This is consistent with recent research on TQM, that has highlighted the importance of going beyond the study of the effects of program adoption, per se, to untangling and separately analyzing the specific practices used by each organization (Powell, 1995; Westphal, Gulati, & Shortell, 1997). A final challenge in studying process management stems from its social desirability. Process management may exist largely as rhetoric in an organization (Hackman & Wageman, 1995; Zbaracki, 1998), complicating survey or interview approaches for collecting data on the actual use of these techniques. Efforts to assess the true extent of adoption, separated from socially-desirable responses, may require extensive observation of organizational activities (Hackman & Wageman, 1995).

An experimental study design, such as I used in the study of groups described here, helps address the above issues. As a process management “condition” is imposed exogenously, through random assignment, the effect of process management on organizational responsiveness can be untangled from other factors that affect both organizational change and adoption of process management. Further, the focus of the experiment is specifically on process management techniques, not on the full range of practices included in programs like TQM. I achieved this focus on process management by simulating the core elements of the ISO 9000

program. ISO 9000's primary focus is on documenting and adhering to organizational processes (Harrington & Mathers, 1997). ISO 9000 program participants are not faced with as wide a variety of tools and techniques, subject to discretionary adoption, as in the case of TQM (Hackman & Wageman, 1995; Harrington & Mathers, 1997). Finally, the experimental setting eliminates the difficulties associated with socially-desirable responses by ensuring that the process management condition is consistent across all groups. Thus, any differential effects between the groups in and out of the experimental condition are likely to be from process management techniques.

Although experimental designs have been employed in previous organizational process literature (e.g. Fredrickson, 1985; Haunschild, Davis-Blake, Fichman, 1994), the primary shortcoming of experiments is in the generalizeability of their results. Actual organizations are more complex than experimental groups, so results obtained in experimental studies of groups may not apply to organizations. Results from experimental studies are thus more useful when combined with more generalizeable findings from studies of organizations. While the findings from this study provide some insight into the likely effects of process management, they must therefore be viewed in light of additional research on process management's role in organizations.

The study was conducted with undergraduate business students at a major university in the fall of 1998. The students were enrolled in a Business and Government course, and were given extra credit for their participation. Out of 32 students enrolled, 26 were in attendance for this research.

Subjects were randomly assigned to eight groups of three subjects each. Each group participated in two rounds of a simulation exercise called *The Supreme Spaceship Manufacturing*

Corporation, designed specifically for this study. Half of the groups were randomly assigned to a condition that simulated the ISO 9000 program. The second round of the exercise involved a simulated technological change in the environment. Response to this environmental change was compared for the two groups.

The Supreme Spaceship Manufacturing Corporation Exercise

In the Supreme Spaceship Manufacturing Corporation exercise, each group represents a spaceship manufacturing company. At the start of the exercise, groups were provided with identical packets of information, including the company mission and objectives, instructions for manufacturing spaceships, a sample spaceship, and instructions to develop a prototype spaceship for approval by the “customer” (researcher). Each group was also provided with raw materials (white paper) and two scissors. The groups were told to work as quickly as possible.

Each spaceship is assembled from eight folded squares of paper, similar to, but more complicated than, making a paper airplane. The “manufacturing” of a spaceship involves cutting and folding paper, and assembling the parts into a completed spaceship. While general instructions were provided to each group concerning how to construct each spaceship “part” from folded paper and how to assemble the parts into a spaceship, decisions about group organization, (i.e. who would make the parts, and who would assemble them) were left to the group.

To ensure that each group was able to make spaceships according to the instructions, groups were given time to practice, and then construct a prototype spaceship to match the sample provided. Once each group had created a matching prototype (approved by the researcher), the group then completed six spaceships for delivery to a customer. The time from approval of the prototype to completion of the six spaceships was recorded in minutes as SPEED1. At the

completion of this round of the exercise, each group had cut, folded, and assembled 56 identical paper parts.

The ISO 9000 program includes a third-party certification program (Harrington & Mathers, 1997). Consistent with this aspect of the program, groups in the ISO 9000 condition were provided with the additional instruction that they would be required to be “certified as a spaceship manufacturer.” They were told that this required that they document their processes and procedures for making spaceships, and adhere to their documented processes. However, they were advised not to begin documenting processes until *after* completion of the customer order for six spaceships. Each group in the ISO 9000 condition was provided with a “certification form” to use in documenting the steps and responsibilities in its processes. As instructed, all groups in the ISO 9000 condition waited until the completion of the six spaceships to document their processes. There were no significant differences in the times for completion of the six spaceships (SPEED1) across the groups, suggesting that instruction-reading and paper-folding skills did not differ significantly for groups within and out of the ISO 9000 condition. After completion of the six spaceships, the ISO 9000 groups then filled out the certification forms documenting their processes.

In the second phase of the exercise, each group was again provided a packet of information, which included a sample of a “technologically-changed” spaceship (described as a competitor’s new design). Groups were instructed that if they could manufacture an exact prototype of this spaceship, they would then receive an order for six more spaceships from their customer. A technological change was simulated through two changes to the spaceship design: First, different colored paper was used for each spaceship part; and second, the spaceship parts varied in size. These spaceship design changes required changes in processes, as paper needed

to be cut differently, and attention paid to alternating sizes and colors. These design changes were not pointed out to the groups. The groups were simply instructed to copy the sample, and were provided with the necessary raw materials (colored paper and scissors). As in the first round, groups were again instructed to first get approval on their prototype from the researcher. The time from receipt of the packet of instructions to approval of a prototype was recorded for each group (SPEED2). Once a prototype had been approved for a group, the group was instructed to manufacture the last six spaceships. The time from prototype approval to completion of the final six spaceships was also recorded for each group (SPEED3).

To ensure that groups in the ISO 9000 condition did not perceive that they were locked into their processes, they were instructed that process improvement changes were allowed, but would need to be recorded on a certification update form following completion of the six new spaceships. All ISO 9000 groups waited until completion of the second set of six spaceships to update their certification forms.

Measures

ISO 9000. The independent variable in this study is a dichotomous variable, coded 1 if the group was assigned to the ISO 9000 condition, and 0 if not.

Organizational adaptation. There are three dependent variables, measured in minutes: 1) SPEED1 is the time required for each group to complete the first six spaceships after having the first prototype approved; 2) SPEED2 is the time for each group to complete the changed prototype after receiving second round instructions; and 3) SPEED2 is the time for each group to manufacture six new spaceships after a new approved prototype. Larger numbers indicate slower adaptation.

These variables can be seen in light of the discussion of technological change above. The technologically-changed spaceship (the competitor's design) represents technological change in the environment. SPEED2, or the time for each team to develop a new prototype to match the competitor's product, can therefore be seen as the time for an organization to adapt to technological innovation in the environment. Following the approval of the changed prototype, the manufacture of the last six spaceships involved working within the existing technology. This can be seen as a period of incremental technology change, as the groups become increasingly efficient at cutting, folding, and assembling spaceship parts. Thus, SPEED3 represents organizational adaptation in stable, or incrementally-changing environments.

T-tests for differences in means or linear regressions provide identical results in this type of analysis. In this case, I chose to run three simple linear regressions with the ISO 9000 condition as the independent variable, and SPEED1, SPEED2, and SPEED3 as the dependent variables, respectively. The equations are in the form:

$$\text{SPEED}_i = \alpha + \beta(\text{ISO}) + \varepsilon$$

where i is 1, 2, or 3 to denote the three dependent variables

Thus a positive (negative) coefficient on the ISO variable represents the longer (shorter) times associated with the ISO 9000 condition.

RESULTS

Means, standard deviations, and correlations are shown in Table 1.

Insert Table 1 about here

Groups completed the first six spaceships in an average of 13.5 minutes, with group times ranging from 11 to 17 minutes. As mentioned above, there were no significant differences between groups within and out of the ISO 9000 condition in the time to complete the first six spaceships (i.e. SPEED1 as the dependent variable). Thus, it is reasonable to conclude that there were no significant underlying differences in the basic approaches the groups used to manufacture spaceships. Results of the regressions analyses are shown in Table 2.

Insert Table 2 about here

SPEED2 represents the time to respond to the technology change. The average response time was 12.5 minutes, with times ranging from 8 minutes to 17 minutes. Hypothesis 2 predicts that process management will be associated with slower response to environmental change. In the regression with SPEED2 as the dependent variable, the coefficient on ISO is positive and significant at $p < .05$ (R-squared = .55), indicating that groups in the ISO 9000 condition took significantly longer to develop an acceptable prototype of the technologically-changed product, providing support for Hypothesis 2. On average, groups in the ISO condition took five additional minutes, or 50% longer to create an acceptable prototype. These results are further borne out by researcher observation. While all the groups recognized and incorporated the color changes immediately in their new prototypes, three of the four groups in the ISO 9000 condition failed to notice the size changes in the spaceship parts. Thus, times for these groups, as represented by SPEED2, were longer, as the groups had to redo half of their prototype. In contrast, only one of the groups outside the ISO condition overlooked the required size changes.

SPEED3 represents adaptation to a stable or incrementally changing environment. Groups averaged 13.4 minutes to manufacture the final six spaceships, with times ranging from 8 minutes to 16 minutes. Hypothesis 1 predicts that process management will be associated with increased efficiency and performance in stable environments. In the regression with SPEED3 as the dependent variable, the coefficient on the ISO variable is negative, that is, ISO 9000 groups took less time to manufacture the final six spaceships, but is not significant. Thus, Hypothesis 1 is not supported. This result is complicated by a missing observation for the SPEED3 variable. One group in the ISO 9000 condition, delayed by not immediately recognizing the size changes in the spaceship parts, requested to leave prior to completion of the final six spaceships.

DISCUSSION

Process management has been widely adopted by organizations in the past decade, often in the form of programs like Total Quality Management, ISO 9000, the Malcolm Baldrige National Quality Award, and Business Process Reengineering. While these approaches are generally intended to increase organizational efficiency and performance, such expectations have not been consistently borne out in empirical studies of the effects of process management (e.g. Powell, 1995). One explanation for the conflicting research results may emerge from consideration of both the stage of technological innovation in an organization's environment, and the effects of process management on organizational response to technological change. Process management may have the potential to increase inertia and channel innovation into incremental forms, impeding responsiveness in the face of radical changes in technology. Conversely, as process management has the potential to improve incremental adaptation in an organization, it is likely to be associated with better performance in periods of incremental technological change.

The experimental study described here is a preliminary attempt to explore the effects of process management on responsiveness to technological change. Findings from the study provide evidence that process management may slow organizational response to technological change, but do not support the hypothesis that process management results in efficiency or performance benefits for organizations in stable environments.

While this study is a useful first step in understanding the effects of process management, it has two obvious limitations. First, the sample size for this preliminary round of the study is very small. The study will be conducted again with about twenty groups of executive MBA students in 1999, which will provide additional data to illuminate the results presented here. Despite the small amount of data, however, the ISO 9000 condition did have a statistically significant effect on a group's ability to respond to a technological change in its environment.

The second limitation of this study is its experimental design using groups, and the potential lack of generalizeability to actual organizations. As discussed above, the findings of this study are most useful when combined with more generalizeable research methods. However, a simulation of the ISO 9000 program has some relevance for the practical experiences of organizations. Since its introduction in 1987, ISO 9000 has been adopted by thousands of companies (Quality Digest, 1998). Many large corporations, such as Siemens, Motorola, Xerox, and Dupont require suppliers to be ISO 9000 certified (Heaphy & Gruska, 1995). In addition, using business student subjects helps increase the external validity of this research, as these students are likely to populate business organizations, and also be involved in programs like ISO 9000. An event after completion of the study illustrates this while also providing a manipulation check of the ISO 9000 simulation. One subject asked if the research was about ISO 9000, as the instructions about process documentation sounded like the ISO 9000 program she had worked on

the previous summer as an intern. Thus, as future organizational participants, these same subjects are likely to be affected by process management, and in turn are likely to affect their organization's response to environmental change.

These results provide support for ideas from organization theory that a focus on incremental innovation and improvement in organizations can affect an organization's ability to recognize and adapt to technological change. Findings in at least one industry (Henderson & Clark, 1990) showed that organizations responded to technological change with incremental extensions of current technology. This study found that such a tendency was further exacerbated by process management.

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TABLE 1
Means, Standard Deviations, and Correlations

Variable	Mean	s.d.	1	2	3
1. ISO	.5	.53			
2. Speed 1	13.5	1.93	.41		
3. Speed 2	12.5	3.59	.69	.64	
4. Speed 3	13.42	2.76	-.15	-.68	-.66

TABLE 2
Results from Regression Analyses

Independent Variable	Models		
	Speed 1	Speed 2	Speed 3
ISO	1.5	5*	-.75
R-squared	.17	.56	.02

* p<.05