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Endogenous Adaptation: The Effects of Technology Position and Planning Mode on IT-Enabled Change*

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ABSTRACT

The redesign of information technology (IT)-enabled work processes often necessitates fundamental design changes to the intended work process, the IT platform hosting the work process, or both. Research suggests that such design changes often can be traced to earlier decisions involving endogenous adaptation or internal organizational change. Two such decisions are a firm's technology position and planning mode. This study examines the relationship between technology position and planning mode in predicting the magnitude of design change in process redesign projects. The conceptual frame applied in examining these relationships involves a synthesis of Miles and Snow's adaptive cycle with elements central to concurrent engineering. Our results indicate that the magnitude of design change is related to differences in technology position and planning mode. To effectively implement organizational change, firms must leverage their IT platform by carefully timing IT investments in accordance with their adopted technology position. Directing the trajectory of a firm's IT platform and deploying it so as to complement the firm's technology position reduces design uncertainty, promoting reengineering success.

Subject Areas: Adaptation, Adaptive Cycle, Adaptive Planning, Concurrent Engineering, Cross-Functional Teams, Design Change, Information Systems Planning, Information Technology Strategy, Integrated Planning, Joint Planning, Process Innovation, Process Redesign, Project Uncertainty, Redesign Strategy, Rework, Synoptic Planning, and Technology Position.

INTRODUCTION

A competitive environment driven by technological change and shorter development cycles has created a formidable challenge for modern organizations—the

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accelerating necessity to rapidly redesign work processes around new developments in information technology (IT). Ironically, process redesign initiatives that possess the potential to provide a firm with a competitive edge also promote substantial risk of failure in their implementation (Sommer & Loch, 2004). Increasingly, the redesign of work processes is enabled by a firm's IT platform, with IT platform investments (e.g., hardware, software, vendor services) contingent on the accurate forecasting of the information and activity requirements of the process being redesigned. The reciprocal nature of this relationship creates an uncertain environment for adaptation.

The uncertainty becomes troublesome when implementation problems surface (i.e., technical and operational glitches) during the end stage of a project—problems that call for change in the design of a work process, its IT platform, or both. In this context, design change refers to the extent of process and/or platform modifications (including the knowledge required to conceive and implement these modifications). The magnitude of these design changes can significantly increase cost and completion estimates, or diminish the expected benefit stream to the point where a project's viability is threatened.

Research indicates that implementation problems, like end-stage design change, often result from upstream decisions (Loch & Terwiesch, 1998; Pich, Loch, & De Meyer, 2002). Two such decisions are technology position and planning mode. Technology position refers to the timing of technology investments relative to one's competitors. Firms typically adopt one of three positions—first mover, early adopter, or late adopter—characterized by respectively lowered levels of technology risk and design uncertainty. We know that *first movers* who implement a novel work process design must coordinate the activities of work process and IT platform development in the face of considerable uncertainty as to where and how those interdependencies exist. *Early adopters*, who hold back on investments until a successful design is revealed, can avoid serious technical and operational problems in that much of this design uncertainty has already been resolved (Mansfield, 1985; Sabherwal & Chan, 2001). *Late adopters*, who imitate a proven design, benefit from the further resolution of design uncertainty at the expense of technical and operational obsolescence.

We recognize that design uncertainty can be reduced through planning. However, the relationship between uncertainty and uncertainty reduction through planning is ambiguous. The planning literature highlights two contrasting methods or modes of planning, synoptic and adaptive, that fall on polar ends of a planning continuum (Segars & Grover, 1999). The *synoptic planning mode* is characterized by the comprehensive integration of planning decisions prior to project implementation. The *adaptive planning mode* is an incremental approach to planning characterized by feedback-driven adjustments as a project unfolds. Confronted with different levels of uncertainty, the prior literature is unclear as to when a synoptic planning mode would prove more effective than an adaptive planning mode.

Classic studies of planning mode found that organizations that tightly coupled functional strategies outperformed organizations that used loose coupling (Thune & House, 1970; Herold, 1972). Subsequent studies both confirm and refute these findings (Grinyer & Norburn, 1975; Malik & Karger, 1975; Wood & LaFarge, 1979; Rhyne, 1986). In an attempt to explain these inconsistencies, later studies took environmental conditions into consideration. These results are also equivocal. Under conditions of uncertainty, Lindsey and Rue (1980) found that synoptic planners outperformed adaptive planners. Contrary to these findings, Kudla (1980), and Fredrickson and Mitchell (1984) report that synoptic planning did not improve performance in uncertain environments. In more stable environments, Fredrickson (1984) observed that synoptic planning was more effective than adaptive planning. In examining factors that influence the speed of product development, Eisenhardt and Tabrizi (1995) found that an adaptive design strategy was most effective under conditions of uncertainty, while a predictive strategy was more effective under conditions of certainty. In a related area, Koufteros, Vonderembse, and Jayaram's (2005) examination of the relationship between cross-functional integration (a synoptic approach) and performance found that uncertainty had little effect on outcomes. Ambiguity relative to rationality and adaptiveness characterizing the synoptic and adaptive modes is also found in the literature on IT planning (e.g., Sabherwal & King, 1992, 1995; Sambamurthy, Zmud, & Byrd, 1994; Segars & Grover, 1999). A multidisciplinary review of the literature suggests that the effect of planning mode on performance is as ambiguous today (Byrd, Sambamurthy, & Zmud, 1995) as it was in the mid-1970s. We shed some light on this debate in the context of IT-enabled process redesign and offer an explanation for the ambiguity.

Our study examines how technology positioning and planning mode affect end-stage design change in the hospital industry. We employ an organizational perspective that is relatively novel in the redesign literature: the adaptive cycle of Miles, Snow, Meyer, and Coleman (1978a). The *adaptive cycle* addresses three fundamental problems—entrepreneurial, administrative, and engineering—that reflect technology position, planning mode, and end-stage design change, respectively. Decisions associated with entrepreneurial and administrative problems are used to define a firm's strategic type, that is, one of the four adaptive paths that constitute the Miles and Snow strategic typology (1978b). Where the strategic typology focuses on exogenous adaptation (adaptation to conditions outside the organization), the adaptive cycle focuses on endogenous adaptation (adaptation to conditions within the organization). The engineering problem has received little attention, as has its effect on adaptation (Zahra & Pearce, 1990). In exploring the nature of IT-enabled process change, our study examines how entrepreneurial and administrative decisions affect the engineering problem of end-stage design change. In doing so, we provide a test of the meaningfulness of the adaptive cycle, in particular its validity regarding endogenous adaptation.

As will be shown, our results indicate that each technology position embodies a different kind of design uncertainty. These differences in design uncertainty call for differences in adaptive decisions to minimize end-stage design changes that can prolong implementation. In order to minimize such design changes, the design uncertainty embedded in a technology position must be alleviated with the proper planning mode. Organizations failing to align their adaptive decisions with a project's emergent design uncertainty are less effective enacting change than are organizations exhibiting alignment.

Given such findings, this study fills an important gap in the adaptation literature by showing how entrepreneurial and administrative decisions affect resolution of the engineering problem. Differences in design uncertainty call for differences in adaptive decisions, and variance in these decisions may account for the inconsistencies reported in earlier studies on exogenous adaptation and organization performance. Miles et al.'s (1978a) and Miles, Snow, Meyer, & Coleman's (1978b) assertion that defenders, analyzers, and prospectors perform equally well has been empirically confirmed and disconfirmed. Incorporating the engineering problem and assessing the impact of adaptive decisions on endogenous adaptations hold promise in enhancing the predictive validity and reliability of their strategic typology.

In the next section, we introduce each adaptive problem and develop a theoretical framework for examining end-stage design change in IT-enabled process redesign projects. Then, we use this framework to develop our research hypotheses, examining the relationship between technology position, planning mode, and end-stage design change. This is followed by explanations of our methodology and the development of our survey instruments. Following this, we describe our data analysis and the use of hierarchical log-linear models. The results of our data analysis are then detailed, followed by a discussion of the findings. We conclude with the implications for research and practice.

THEORETICAL FRAMEWORK

One approach to understanding end-stage design change is to view process redesign as an organizational adaptation. The adaptive cycle of Miles et al. (1978a) is grounded in the notion of strategic choice, that is, choices made by management are critical determinants of organizational structure and processes. A basic premise behind this notion is that organizations act to create their environments, and the enactment of that environment is constrained by existing knowledge of alternative organizational responses to salient environmental forces (Segars & Grover, 1999). Thus, effective organizational adaptation hinges on management's perceptions of environmental conditions, decisions it makes concerning how the organization will cope with these conditions, and the knowledge available to support those decisions.

Each exogenous adaptation requires the resolution of three adaptive problems. The entrepreneurial problem focuses on how to position an organization in the marketplace. The engineering problem focuses on how to design structures and processes in light of the entrepreneurial decision. The administrative problem, then, both leads and lags the other two problems (Dvir, Segev, & Shenhar, 1993). As a lagging problem, the question is how to install the structures and processes emanating from the engineering decision. To address this problem, administrators make a number of critical decisions concerning time, resource deployment, and change management that influence project outcomes. As a leading problem, the issue is the degree to which these decisions can be articulated a priori without constraining future adaptations. Although described in a sequential manner, in most organizations these problems overlap, and the adaptive cycle is iterative (Miles et al. 1978b).

The pattern of decisions in the adaptive cycle defines an adaptive path. Four paths were identified by Miles et al. (1978a), which gave rise to their popular strategic typology. The typology allows organizations to be classified (as a defender, analyzer, prospector, or reactor) based on a common profile of adaptive decisions and differences in performance that can be attributed to these decisions (Meyer, Tsui, & Hinings, 1993). Past empirical studies have supported the typology's predictive validity for industry-specific performance (Smith, Guthrie, & Chen, 1989; Shortell & Zajac, 1990). However, a comparison of firm performance across industries produces inconsistent results regarding the extent to which defenders, analyzers, and prospectors are more, less, or equally effective relative to each other (Zahra & Pearce, 1990).

One explanation for these inconsistencies is a truncated adaptive cycle. Studies using the typology have categorized organizations based on entrepreneurial and/or administrative decisions (see reviews by Shortell & Zajac, 1990; Zahra & Pearce, 1990). Although valid and reliable measures have been developed for these adaptive decisions, the omission of engineering decisions indicates that the adaptive cycle is not completely operationalized. Shortell and Zajac (1990) conducted a comprehensive assessment of the validity and reliability of Miles and Snow's strategic typology. While their findings validate measures of the entrepreneurial and administrative dimensions, the engineering dimension could not be assessed as it has been omitted from studies employing the typology. Shortell and Zajac call for greater attention to the technical domain, particularly its measurement and how it impacts other dimensions.

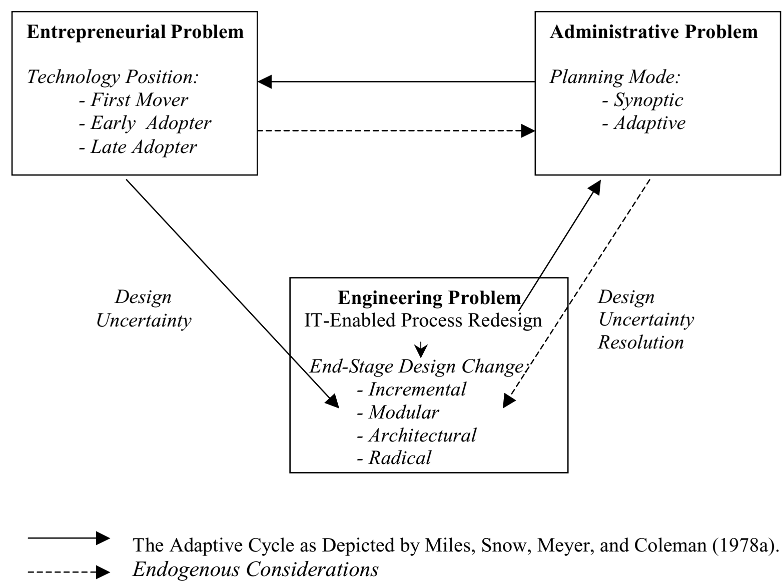
A second explanation for the inconsistent findings is that implementation differences (in enacting an internal environment) confound the relationship between an organization and its external environment (Segev, 1987, 1989). Miles et al. (1978b) assert that adaptation is a cycle of adjustment among innovation, process, and technology. How an organization manages its internal adaptive cycle (i.e., the nature of the technological and process designs, their novelty, and the subsequent resolution of design) determines its alignment with the external environment.

Our study examines endogenous adaptation using all three dimensions of the adaptive cycle. We measure the influence of entrepreneurial and administrative decisions on the implementation of engineering decisions. In keeping with prior research, we operationalize the entrepreneurial decision as technology position (Goodman & Lawless, 1994) and administrative decisions as planning mode (Segev, 1987). Departing from prior research, we extend the adaptive cycle by including engineering decisions that capture deviations from the initial design of a new work process and its enabling IT platform. We examine patterns of technology position and planning mode associated with four types of end-stage design change (depicted in Figure 1), with these end-stage design types reflecting varying degrees of implementation change. In doing so, we extend the use of Miles and Snow's adaptive cycle to endogenous (internal) organizational adaptations, incorporate the engineering problem, and provide additional insight to reduce implementation risk. Next, we describe each adaptive problem in the context of IT-enabled process redesign.

The Engineering Problem: End-Stage Design Change

IT-enabled process redesign projects are prime examples of endogenous adaptations that meld two distinct yet related subsystems—an evolving work process hosted by an evolving IT platform. The benefits of a new process design stems

Figure 1: Miles and Snow's adaptive cycle applied to endogenous adaptations.



from the knowledge embedded in the core design of its component tasks and how those tasks are linked together. Similarly, an IT platform embodies knowledge regarding a set of IT components (i.e., hardware, software, and databases) and their linkages (e.g., network configuration), which, taken together, provide the foundation for process change. Systematic consideration of IT components and linkages in the context of process activities allows redesign planners to determine the firm's IT competencies and limitations and then exploit, or "work around," these technological realities in designing new processes (McDonald, 1991).

The design of a new work process and its IT platform captures the essence of the engineering problem: how to organize operations. Successful reorganization—in this context, the redesign of work processes—is dependent on management's ability to anticipate, moderate, and (ideally) eliminate design uncertainties that contribute to implementation risk. *Implementation risk* refers to the likelihood of foregone benefits, unanticipated costs, and longer time to completion that can be traced to implementation difficulties (Applegate, McFarlan, & McKenny, 1999). When the redesign environment is analyzable and stable, it is more likely that process and platform designs can be implemented as intended, delivering expected benefits on time and within budget. As the process–platform relationship becomes more unpredictable, implementation impediments (e.g., unexpected information and technology requirements) arise for which further design changes become more likely (Mitchell & Zmud, 1999). The later these design changes occur in the project's life cycle, the more difficult it is to deliver the expected benefits within the projected budget and completion period.

End-stage design change refers to work process or IT platform design modifications that typically result from difficulties arising during implementation—the end stage of the project life cycle. Borrowing concepts from Henderson and Clark (1990), and adapted by Mitchell and Nault (in press), we define four types of design change that differ in the extent to which modifications are required in design components (elements of an IT platform or tasks in a work process) or in the linkages among these components. An *incremental change* involves minor changes to design components and does not affect component linkages. A *modular change* substitutes new components for one or more components in the failed process or IT platform design, but does not affect the linkages among components. An *architectural change* reconfigures the intended process or supporting platform by changing the linkages of design components, but does not replace the components. Finally, a *radical change* involves a completely new design, characterized by both new components and revised linkages among new and old components. Design change involving linkages (architectural and radical change) are more difficult to enact than those confined to components (modular change) due to the inherent complexities of system interdependence (Henderson & Cockburn, 1994). Thus, implementation risk is greater for architectural and radical design changes than for incremental and modular design changes.

The Entrepreneurial Problem: Technology Position

The entrepreneurial problem addresses the question of how to position the firm in a market. An important market for firms contemplating IT-enabled change is the technology market. How a firm situates its process and IT relative to competitors is indicative of a technology position. We define technology position as a pattern of investment in the technologies diffusing through an industry. Investments are made in three broad classes of technology: base, key, or pacing (Erickson, Magee, Roussel, & Saad, 1990; Goodman & Lawless, 1994). Base technologies form the technical core of the business, a necessary investment to remain competitive. Base technologies tend to be widely known and available to competitors. Key technologies provide the firm with a competitive advantage. In adapting a key technology, firms embed an idiosyncratic feature that enables new functionalities or efficiencies not easily replicated by competitors. Finally, pacing technologies are new developments, process or product innovations, that have the potential to change the basis of competition (Erickson et al., 1990). The timing of a firm's technology investment in base, key, or pacing technologies is indicative of its technology position in a given industry (Goodman & Lawless, 1994).

A firm can adopt one of three technology positions—first mover, early adopter, or late adopter—in the integration of technology and business strategies. First movers tend to be process innovators who emphasize technological leadership and readily invest in pacing technologies to facilitate organizational change (Dvir et al., 1993). Early adopters are the initial imitators who monitor the actions of technology leaders, then replicate those actions after a thorough analysis of the market opportunities and operational consequences. These imitators invest in key technologies by refining newly introduced but proven pacing technologies. Late adopters primarily invest in proven, base technologies and established processes that allow them to maintain their competitive stance (Miles et al., 1978a). These investment patterns thus reflect a firm's orientation toward innovative activities.

Studies suggest entrepreneurial decisions, particularly level of innovation, capture the essence of Miles and Snow's adaptive types (Hambrick, 1983). First movers, who invest in pacing technologies to search for opportunities and create industry change, characterize the Prospector strategy (Matsuno & Mentzer, 2000). Early adopters, who verify the feasibility of change before investing in key technologies, reflect the Analyzer strategy. Late adopters, who tend to ignore new developments outside their domain and focus on refining base technologies, typify a Defender strategy (Sabherwal & Chan, 2001). The fourth adaptive type, Reactor, employs aspects of the other adaptive strategies depending on perceived changes in the environment (Miles et al., 1978a). Because they lack a consistent response mechanism to environmental pressures, Reactors offer no basis for comparison across adaptive decisions (Zahra & Pearce, 1990). Thus, a priori predictions cannot be made regarding their behavior; so they have generally been excluded from hypothesis testing.

The Administrative Problem: Planning Mode

The administrative problem of how to create new work processes bridges the entrepreneurial and engineering problems. Technology position is enacted through new work processes, and process change comes about through planning. Planning refers to a pattern in a stream of actions undertaken to develop a program, product, or service (Mintzberg & Waters, 1985). Miles and Snow's adaptive types are business strategies enacted through functional-level plans (Mintzberg, 1994). Two interdependent functional plans pertinent to IT-enabled change are the redesign and IT plans. The initial blueprint for process redesign is embodied in a redesign plan, and IT platform evolution is captured in an IT plan. Mutual consideration of these plans is necessary for redesign success (Madnick, 1991). The pattern of activity producing these plans defines the planning mode or method. Two very distinctive planning modes exist in the strategy literature—synoptic planning and adaptive planning.

Synoptic planning embodies the rational model of decision making. This model assumes (i) that a comprehensive, systematic analysis of the environment and organizational situation reduces uncertainty and (ii) that uncertainty reduction enables the recognition and removal of implementation impediments that would otherwise limit organization performance (Fredrickson, 1984). Strategic intentions are formulated as precisely as possible and implemented with minimal deviation from the intended plan. This is accomplished by scanning the environment, establishing goals, assessing internal capabilities, determining means, and the comprehensive integration of planning decisions, all prior to implementation (Fredrickson, 1983; Segars & Grover, 1999).

The adaptive planning mode is derived from the incremental school of strategy formulation (Mintzberg, 1973). This planning mode is based on the principle of intended rationality, positing that under conditions of uncertainty, cognitive and process limits make synoptic planning infeasible and unpredictable (Quinn, 1980). Instead, the planning process and its implementation are intertwined in a repetitive process of feedback-driven adjustments until a successful design emerges (Lindbloom, 1959; Joyce, 1986). Strategic intentions are not well defined, but rather emerge from successive decisions in response to remediation (Sabherwal

& King, 1995; Lederer & Sethi, 1996). Adaptive planning is characterized by limited environmental scanning, indeterminate goals, recurrent and simultaneous ends-means assessment, with little attempt to integrate decisions prior to implementation. In doing so, flexibility can be maintained in responding to conditions as they unfold. This planning mode underlies the systematic remedial change in process improvement (Juran & Godfrey, 1999) and rolling plans in e-commerce (Earl & Kahn, 2001).

DEVELOPMENT OF RESEARCH HYPOTHESES

Endogenous Adaptation: Minimizing End-Stage Design Change

IT-enabled change initiatives require the mutual consideration of redesign and IT strategies to effectively reduce design uncertainty and implementation risk (Nidumolu, 1995). The redesign strategy addresses the coordinated actions associated with a redesign project's work process and IT designs (Madnick, 1991). This agenda sets the context in which the IT platform is enhanced and then exploited. Thus, a firm's ability to successfully introduce IT-enabled change is a function of its investment in, and management of, its IT platform. These decisions are incorporated into a firm's IT strategy. Given the reciprocal interdependence between work process and IT platform designs, prior research suggests that design uncertainty can be reduced when IT managers are involved in business unit planning and business units are involved in IT planning (Boynton, Zmud, & Jacobs, 1994; Horner-Reich & Benbasat, 1996). How formal and comprehensive these activities should be for a given technology position captures the synoptic-adaptive decision underlying the administrative problem.

Previous research suggests that different technology positions call for different planning modes to effectively reduce implementation risk. In their study of IT-enabled redesign projects in the health care sector, Mitchell and Zmud (1999) report higher project performance when redesign and IT strategies are tightly coupled for process inventions (pacing technologies) and loosely coupled for process imitations (key and base technologies). In a related study on concurrent design, Mitchell and Nault (in press) found that uncertainty increased the magnitude of upstream (work process) rework but not downstream (IT platform) rework. They also found that the magnitude of both process and platform rework is mitigated by the amount of cooperative planning and cross-functional team involvement. These empirical findings support the views expressed by others (e.g., Adler, 1995; Terwiesch, Loch, & De Meyer, 2002): that design uncertainty is substantially reduced through the extensive coordination of IT capabilities with process requirements. However, where less uncertainty exists, greater planning flexibility is beneficial to the integration of new processes or new IT within the existing infrastructure. While Mitchell and Zmud (1999) relate the entrepreneurial and administrative dimensions of the adaptive cycle to project performance (an outcome of the adaptive cycle), the effect of these dimensions on the engineering problem is less clear. We extend these earlier findings by incorporating a major engineering problem, end-stage design change.

In order to minimize end-stage design change, first movers are best served by synoptic planning, because synoptic planning reduces more uncertainty early, thereby improving predictability of project outcomes (Terwiesch & Loch, 1999).

These improvements in predictability lead to less design change. In a synoptic planning mode, first movers scan the environment for trends and new ideas. Based on these trends and new ideas, they identify and articulate their goals. They then assess existing capabilities, comparing these with the requirements necessary to achieve the articulated goals. To assure that requirements are met, formal plans are developed for the systematic acquisition and deployment of project resources. This enables first movers to introduce a viable IT platform prior to implementation.

In IT-enabled designs, this translates into scanning the environment for new ideas regarding the application of IT. Based on these new ideas, first movers formulate goals for enacting a novel work process using IT. Information requirements for the intended process are identified, and the ability to meet those requirements assessed. This culminates in a formal plan, delineating the acquisition and deployment of project resources. First movers engaged in synoptic planning articulate and integrate both a redesign plan and an IT plan. Integration requires an exchange of information among IT and work process designers; and for first movers, this exchange needs to take place before IT resources are committed to action. If a thorough assessment of IT capabilities occurs and comprehensive plans are prepared to eliminate deficiencies and anticipate requirements, the design uncertainty associated with pioneering a new process is minimized (Sambamurthy et al., 1994). This gives rise to our first hypothesis:

H1: First movers minimize end-stage design change with synoptic planning.

In order to minimize end-stage design change, late adopters are best served by adaptive planning. Adaptive planning reduces uncertainty through successive feedback-driven adjustments. Redesign through an incremental approach permits flexibility in modifying the technical core while maintaining operational stability. Limited modification allows for greater operational control, lowering the likelihood of end-stage design change. In an adaptive planning mode, little attention is given to monitoring trends until an operational efficiency has been demonstrated. Goals are unspecified as objectives may change in response to prior adjustments. Analysis and implementation are intertwined in a series of disjointed decisions until a satisfactory solution emerges.

In IT-enabled process design, adaptive planning would translate into successive incremental adjustments to the existing IT platform so as to allow for greater control of the change process and the preservation of IT functionalities serving other parts of the organization. Late adopters engage in environmental scanning to monitor the application of IT for economies of scale or operating efficiencies. Operational goals are rarely articulated as redesign and IT objectives change to resolve problems encountered as the project unfolds. Requirements analysis and implementation take place in an iterative fashion, allowing for flexibility in making IT investments as process needs become known. This reasoning leads to our second hypothesis:

H2: Late adopters minimize end-stage design change with adaptive planning.

Where first movers and late adopters define opposite ends of a continuum, early adopters are positioned in between (Doty, Glick, & Huber, 1993). They emphasize stability in their technical core, although they quickly imitate the successful actions of others. In order to minimize end-stage design change, early adopters are apt to employ aspects of both synoptic and adaptive planning—termed a *mixed planning mode* (Mintzberg, 1973). Characteristic of synoptic planning, early adopters scan the environment for successful innovations, thus avoiding the cost of research and development. Prior to adoption, they conduct a thorough assessment of their current operation's capabilities and limitations, and then formulate their goals for deployment. Characteristic of adaptive planning, early adopters rely on feedback-driven adjustments to deploy the innovation. Progressive feedback allows for controlled experimentation with the technical core. The mixed mode integrates formal analysis with serial design (Sabherwal & King, 1995; Chan, Huff, Barclay, & Copeland, 1997). Comprehensive analysis provides the goals for design, while incrementalism permits flexibility in design, which allows for the preservation of adjacent operations.

In an IT-enabled change context, early adopters monitor the activities of competitors who have introduced electronic processes. Once an IT-enabled process proves successful, they quickly replicate these activities, including IT support. In preparation for imitation, early adopters conduct a thorough analysis of process requirements and existing IT capabilities to meet those requirements. Based on that analysis, goals are formulated to eliminate deficiencies and direct process implementation. Implementation takes place incrementally, with successive steps in IT investment and process adjustments. An iterative cycle allows feedback regarding process activities and IT components to be incorporated into the next round of adjustments. Through comprehensive planning, process activities and IT support are tightly integrated, providing a blueprint for change. Implementing that blueprint incrementally, investments in the IT platform are made successively, based on process needs as the project unfolds. Serial IT investments permit flexibility in platform design, to work around constraints in process design. Likewise, as IT capabilities are realized, process design is altered to take advantage of those capabilities. Small successive adjustments to both process and platform design preclude major change as the project unfolds. This reasoning culminates in our third hypothesis.

H3: Early adopters minimize end-stage design change using a mixed planning mode.

The hypothesized relationships between technology position, planning mode, and end-stage design change are highlighted in Table 1.

Table 1: Technology position, planning mode, and hypothesized design change.

	Planning Mode	
Technology Position	Adaptive Planning	Synoptic Planning
	End-stage design change:	End-stage design change:
First mover	Architectural and Radical	Incremental and Modular
Early adopter	Incremental and Modular	Incremental and Modular
Late adopter	Incremental and Modular	Architectural and Radical

RESEARCH METHODOLOGY

Data Collection

Data were collected over the past decade as part of a larger research program on the impact of IT in health services. The sampling frame consisted of 183 multi-hospital systems engaged in process redesign, particularly first-time IT-enabled process conversions, as identified by the popular press (e.g., *The Wall Street Journal*, *Modern Healthcare*, *Business Week*), private agencies (e.g., Robert Wood Johnson Foundation, American Nursing Informatics Association), and government offices. A total of 366 project managers and IT managers were contacted by telephone, informed of the study, and asked to participate. If agreement was obtained, these individuals were asked specific questions to gather information about the old work process, its replacement, and project delays, and they were asked to complete a mailed survey. Managers failing to complete their surveys after a month were contacted, and the survey was conducted by telephone. The interview questions and survey instruments are provided in the Appendix.

Project managers and IT managers were queried with a different subset of survey questions. Using IT managers to collect data on three constructs (planning mode, IT design change, and user acceptance), and project managers for the other five constructs (technology position, process design change, IT delay, schedule slippage, and budget overrun) removed the threat of a single-source bias in the responses. In total, sets of matched surveys were obtained for 121 IT-enabled process redesign projects. Project duration ranged from 4 months to 9 years, with an average completion time of 10 months. Of that, 6 months was the average time lost due to unanticipated design modifications.

Instrument Development

Borrowing a validated instrument previously used to collect data on the coupling of work process and IT strategies and concurrent process-IT design (Mitchell & Zmud, 1999; Mitchell & Nault, in press), we utilized 10 of their items and added an additional 6 items to better reflect the entrepreneurial, engineering, and administrative dimensions outlined by Miles, Snow, Meyer, and Coleman (1978a). We also used four-item Guttman scales to capture work process and IT platform design changes employed by Mitchell and Nault (in press) in their study on concurrency and rework. To relate design changes to implementation risk, we measured four project outcomes: IT delay, overall schedule slippage, budget overrun, and user acceptance. Project managers were asked about delays during the telephone interview and about budget overruns in the survey instrument. We used two objective measures of delay—duration of the longest IT-related schedule slippage and overall schedule slippage. Overall schedule slippage was calculated by subtracting the initial completion date from the actual completion date. For budget overrun and user acceptance, we used two items adapted from Pinto and Slevin's (1986) Project Implementation Profile. Raw scores from these items were used in a post hoc correlation analysis. Again, to reduce response bias, IT managers, rather than project managers, were queried about user acceptance.

A pilot study was conducted to evaluate the meaning, ordering, and representativeness of survey items. We sent the instruments to five hospitals for review by redesign managers and IT managers regarding the intended issues and concepts. Upon receipt of completed surveys and comments, we interviewed 10 respondents by telephone to obtain further feedback on the instrumentation (Stone, 1978; Converse & Presser, 1986). We then sent the instruments to project and IT managers in 43 hospitals to conduct a preliminary analysis. Based on that analysis, one item, "The redesigned process is similar to process designs used in other areas of our organization," was culled from the pilot survey due to its low factor loading (.4398). The refined survey instruments were sent out as redesign projects were completed.

Analysis

We used principal components analysis to validate our measurement scales. Then, we performed a cluster analysis to categorize the technology position and planning mode employed by each project. The Guttman scales provided mutually exclusive categories for end-stage design change. Considering that all of our variables were categorical, we used hierarchical log-linear (hilog) models to estimate the likelihood of each type of design change relative to the technology position and planning mode adopted. Hilog models do not distinguish between independent and dependent variables, but rather treat all variables as "response" variables, whose mutual associations are explored as expected frequencies in a cross-tabulation (Knoke & Burke, 1980).

Principal components analysis was used to define the scales for technology position and planning mode. Tables 2–4 suggest both convergent and discriminant validity for these two constructs (Kerlinger, 1986). In Table 4, primary factor loadings exceeded the .722 critical value for significance for all items (Stevens, 1986) except one. The item "redesign to create a competitive advantage" was retained with a factor loading of .683, as it is sufficiently close to .722 to be representative of intent to create a competitive advantage, a key indicator of adaptive type. There was a high degree of internal consistency among items as indicated with a Cronbach's alpha coefficient of .81 when the scales were combined (Stone, 1978). Reliability analysis for the individual scales yielded a Cronbach's alpha of

Table 2: Correlation matrix for technology position items.

Items	TP1	TP2	TP3	TP4	TP5	TP6
TP1	1.000					
TP2	.899	1.000				
TP3	.601	.520	1.000			
TP4	.408	.410	.668	1.000		
TP5	.502	.458	.830	.866	1.000	
TP6	.338	.404	.628	.967	.837	1.000

Table 3: Correlation matrix for planning mode items.

Items	PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9
PM1	1.000								
PM2	.821	1.000							
PM3	.714	.603	1.000						
PM4	.755	.669	.734	1.000					
PM5	.760	.655	.756	.779	1.000				
PM6	.707	.617	.732	.643	.769	1.000			
PM7	.836	.740	.785	.830	.891	.747	1.000		
PM8	.666	.557	.705	.628	.772	.950	.743	1.000	
PM9	.648	.589	.635	.823	.732	.626	.756	.589	1.000

Table 4: Factor matrix.

Factor 1 Technology Position	Factor 2 Planning Mode	Item Content
.914	−.114	This design was adopted because of its proven usefulness in the industry*
.885	−.115	The redesigned process is unique, no one else is using it
.866	−.108	The redesigned process is a major departure from previous operations
.837	−.187	The redesigned process is a de facto industry standard*
.720	−.009	The process was redesigned in anticipation of future industry trends
.683	−.145	The process was redesigned to create a competitive advantage
−.174	.870	The business unit had a formal redesign plan
−.006	.801	Our organization has a formal IT plan
−.193	.834	Business unit personnel were involved in IT planning
−.006	.882	IT personnel were involved in redesign planning
−.232	.839	The information and IT needs of the redesign project were considered when formulating the IT plan
−.007	.913	IT strengths and limitations were considered in redesign project planning
−.003	.949	Redesign goals were clear to IT personnel prior to process implementation
−.242	.815	Alterations to the IT platform were made as a specific project need arose*
−.180	.800	Alterations to the IT platform were anticipated prior to process implementation

*Item is reverse coded.

.907 for technology position and .959 for planning mode. This two-factor solution explained 73.3% of the variance in the data set. Factor 1 denotes technology position and Factor 2 the planning mode adopted.

Next, factor scores were collapsed into polytomous variables using cluster analysis. Ward's method, based on minimum variance and maximum likelihood, provided a conservative estimate of the number of distinct groups (Milligan &

Isaac, 1980). The SAS Fastclus algorithm was used in conjunction with the Aceclus procedure to determine group membership. The Aceclus procedure transforms the variable factor scores according to an estimated within-cluster covariance matrix. Fastclus assigns membership based on minimizing the sum of squared euclidean distances from cluster means (Anderberg, 1973). Results of the cluster analysis are provided in Table 5. Three clusters were obtained for Factor 1 (technology position) that reflect first mover, early adopter, and late adopter positions. Two clusters were obtained for Factor 2 (planning mode). These clusters distinguish synoptic from adaptive planning. An analysis of variance among cluster means indicates significant differences among the groups. Table 6 presents the distribution of projects across cluster groupings.

Next, we used a hierarchical log-linear (hilog) model to assess the likelihood of an association among technology positions, planning modes, and end-stage design change. Log-linear analysis is an appropriate technique for assessing such relations when the response variables (e.g., work process and IT design change) are categorical and the data is not from a normally distributed population. We used the following saturated hilog model to capture all interaction and main effects influencing the likelihood of end-stage design change during process implementation.

Table 5: Cluster analysis of factor scores for technology position and planning mode.

	Cluster 1	Cluster 2	Cluster 3	*F* statistic (*p* value)
Technology position	First mover −1.2658 (n = 28)	Early adopter .0105 (n = 62)	Late adopter 1.1002 (n = 31)	498.805 (.000)
	Cluster 1	Cluster 2	*F*-statistic (*p*-value)	
Planning mode	Adaptive −1.0990 (n = 47)	Synoptic .6980 (n = 74)	406.272 (.000)	

Table 6: Number of projects by technology position and planning mode.

Cluster Membership	Adaptive Planning	Synoptic Planning	Total	Percentage
First mover	12	24	36	34%
Early adopter	16	28	44	36%
Late adopter	19	22	41	30%
Total	47	74	121	100%
Percentage	39%	61%	100%	

$$lnF(\text{process design change, IT design change, technology position, planning mode})_{ijkl}$$
$$= M + L_i + L_j + L_k + L_l + L_{ij} + L_{ik} + L_{il} + L_{jk} + L_{jl} + L_{kl} + L_{ijk} + L_{ijl}$$
$$+ L_{ikl} + L_{jkl} + L_{ijkl},$$

where

lnF_{ijkl} = the natural log of the frequency of a work process design change, with an IT design change, given a particular technology position and planning mode,

M = average of the logs of frequencies of all model cells,

L_i = the likelihood of a particular work process design change (incremental, modular, architectural, or radical),

L_j = the likelihood of a particular IT design change (incremental, modular, architectural, or radical),

L_k = the likelihood of adopting a particular technology position (first mover, early adopter, or late adopter),

L_l = the likelihood of adopting a particular planning mode (synoptic or adaptive),

L_{ij} = the likelihood of a particular work process design change with a particular IT design change,

L_{ik} = the likelihood of a particular work process design change, given a particular technology position,

L_{il} = the likelihood of a particular work process design change, given a particular planning mode,

L_{jk} = the likelihood of a particular IT design change with a particular technology position,

L_{jl} = the likelihood of a particular IT design change with a particular planning mode,

L_{kl} = the likelihood of enacting a particular technology position with a particular planning mode,

L_{ijk} = the likelihood of a work process design change with a particular IT design change while enacting a particular technology position,

L_{ijl} = the likelihood of a work process design change with a particular IT design change while employing a particular planning mode,

L_{ikl} = the likelihood of a work process design change while enacting a particular technology position and employing a particular planning mode,

L_{jkl} = the likelihood of an IT design change while enacting a particular technology position and employing a particular planning mode, and

L_{ijkl} = the likelihood of a work process design change with a particular IT design change while enacting a particular technology position and employing a particular planning mode.

In a hierarchical model, all main effects and lower-order interactions are subsumed in the highest-order interaction term in which they appear—called the

Table 7: Tests of partial associations.

Model Term	df	χ^2 Partial	*p* value	Iterations
Technology position × Planning mode × Process change	6	14.533	.0242*	5
Technology position × Planning mode × IT change	6	13.505	.0357*	5
Planning mode × Process change × IT change	9	9.689	.3763	10
Technology position × Process change × IT change	18	18.224	.4410	12
Technology position × Planning mode	2	4.520	.1044	7
Planning mode × Process change	3	20.047	.0002	5
Technology position × Process change	6	30.056	.0000	7
Planning × IT change	3	8.017	.0457	5
Technology position × IT change	6	13.090	.0416	7
Process change × IT change	9	58.140	.0000*	5
Planning mode	1	6.076	.0137	2
Technology position	2	.818	.6644	2
Process change	3	42.049	.0000	2
IT change	3	58.124	.0000	2

*Highest-order significant terms not subsumed in other terms = reduced model.

generating class. In our saturated model, the generating class is the four-variable interaction term representing all combinations of relationships involving technology position, planning mode, and each type of end-stage design change. To isolate the significance of lower-order interactions, we evaluated the contribution of individual terms using partial chi-square tests. Much like a change in R^2 in multiple regression models, the change in chi-square (or partial chi-square) captures that term's contribution to the model. These results are provided in Table 7. Based on significant partial chi-square values, the generating class for the final hilog model is reduced to

$$lnF(\text{process design change, IT design change, technology position, planning mode})_{ijkl}$$
$$= M + L_{ij} + L_{ikl} + L_{jkl},$$

where

M = average of the logs of frequencies of all model cells,

L_{ij} = the likelihood of a particular process design change with a particular IT design change,

L_{ikl} = the likelihood of a process design change while enacting a particular technology position and employing a particular planning mode, and

L_{jkl} = the likelihood of an IT design change while enacting a particular technology position and employing a particular planning mode.

The final model has a likelihood ratio chi-square statistic of 58.72 and a significance value of .523, indicating that it is a good representation of the underlying data. Note, in hilog models, it is the sign of the likelihood estimator that determines the nature of the outcome (Knoke & Burke, 1980). The largest positive parameter estimate represents the most likely outcome. Results from the final model are provided in Tables 8–10, with most likely outcomes in boldface type.

The stability of the parameter estimates derived from the final model was tested using a nonparametric bootstrapping procedure and paired *t* tests (Mooney & Duval, 1993). The nonparametric bootstrap is a generalized jackknife procedure of re-sampling with replacement that provides an estimate of bias and variance in the hilog results (Efron & Tibshirani, 1993). We ran our hilog model 121 times with $n-1$ cases, where a different case was dropped with each run, then replaced in subsequent runs. Parameter estimates from each run were compared with the full model estimates using paired *t* tests to discern a difference in mean parameter values. All estimates were found to be stable, as final model estimates did not differ statistically from partial model estimates. Thus, the model is robust to variations in the data set with little change in the parameter estimates.

EMPIRICAL FINDINGS

Our results indicate that endogenous adaptation is most effective when first movers use synoptic planning, when late adopters use adaptive planning, and when early adopters use a combination of planning modes. Tables 8–10 provide a breakdown of our hilog results. An examination of the parameter estimates in Table 8 indicates a synoptic planning mode minimizes process design change for first movers ($L_{ikl} = .38356$) and early adopters ($L_{ikl} = .22381$), while an adaptive planning mode is most effective for late adopters ($L_{ikl} = .27241$). Table 9 highlights IT platform outcomes. It suggests that synoptic planning minimizes end-stage design change for first movers in IT ($L_{ikl} = .31165$), while early and late adopters benefit more from adaptive planning ($L_{ikl} = .25512$ and .29836, respectively). The juxtaposition of work process and IT platform design changes is presented in Table 10. An incremental IT design change is most likely to occur with incremental and modular work process change, while architectural and radical IT changes are, respectively, paired with radical and architectural process change.

Table 11 provides a synthesis of the above results, emphasizing which design changes are most likely to occur for a given set of adaptive decisions. First movers are more likely to encounter modular process change and incremental

Table 8: Final hilog results—likelihood of work process (WP) design change by technology position and planning mode.

	Incremental WP	Modular WP	Architectural WP	Radical WP
Adaptive Planning				
First Mover	.03299	−.38356	**.21946**	.13111
Early Adopter	−.22381	**.11115**	.06858	.04408
Late Adopter	.19082	**.27241**	−.28804	−.17519
Synoptic Planning				
First Mover	−.03299	**.38356**	−.21946	−.13111
Early Adopter	**.22381**	−.11115	−.06858	−.04408
Late Adopter	−.19082	−.27241	**.28804**	.17519

Note: Boldface type indicates most likely outcomes.

Table 9: Final hilog results—likelihood of IT platform design change by technology position and planning mode.

	Incremental IT	Modular IT	Architectural IT	Radical IT
Adaptive Planning				
First Mover	−.31165	−.19755	.17369	**.33551**
Early Adopter	.01329	**.25512**	−.17838	−.09003
Late Adopter	**.29836**	−.05757	.00469	−.24548
Synoptic Planning				
First Mover	**.31165**	.19755	−.17369	−.33551
Early Adopter	−.01329	**.25512**	.17838	.09003
Late Adopter	−.29836	.05757	−.00469	**.24548**

Note: Boldface type indicates most likely outcomes.

Table 10: Final hilog results—likelihood of work process design change and IT platform design change.

Design Change	Incremental IT	Modular IT	Architectural IT	Radical IT
Incremental WP	**.49205**	.01108	−.39740	−.10573
Modular WP	**.87948**	−.01797	−.39561	−.46590
Architectural WP	−.78795	−.00720	.24961	**.54554**
Radical WP	−.58358	.01409	**.54340**	.02609

Note: Boldface type indicates most likely outcomes.

Table 11: Synthesis of hilog results.

	Planning Mode	
Technology Position	Adaptive Planning	Synoptic Planning
	End-stage design change:	End-stage design change:
First Mover	Architectural process change	Modular process change*
	Radical IT change	Incremental IT change*
Early Adopter	Modular process change*	Incremental process change*
	Modular IT change*	Architectural IT change
Late Adopter	Modular process change*	Architectural process change
	Incremental IT change*	Radical IT change

*Hypotheses supported.

platform change with synoptic planning and are more likely to encounter architectural process change with radical platform change under adaptive planning. The reverse holds for late adopters. They are more likely to experience modular process change and incremental platform change with adaptive planning and are more likely to encounter architectural process change with radical platform change under synoptic planning. It is interesting to note that first movers and late adopters experience the same design change with different planning modes, reflecting the need to align technology position and planning mode. Between these polar ends are early adopters, who benefit from both planning modes. These imitators tend to experience modular process and platform change with adaptive planning, although incremental process change tends to result from synoptic planning.

To ascertain the impact of end-stage design change on implementation, we conducted a post hoc correlation analysis of design change and the four project measures of IT delay, schedule slippage, budget overrun, and user acceptance. To conduct the analysis, we coded the design change categories using an ordinal scale. An ordinal scale permits measurement of the differences among categories based on a characteristic, without indicating the amount of difference. We ranked design changes according to the increasing levels of complexity associated with each type of design modification. Thus, we assigned scores of 1, 2, 3, and 4, respectively, to incremental, modular, architectural, and radical design change. We ranked architectural design change higher than a modular change, because modification of the interdependencies among components is more multifarious than substitution or modification of individual components (Henderson & Cockburn, 1994).

Bivariate correlations among types of design change and each project outcome indicate that end-stage design change is a significant source of implementation risk (Table 12). As expected, the degree of end-stage design change in IT coincides with the degree of end-stage design change in work processes. We find that more extensive end-stage process and IT design changes (architectural and radical change) are associated with longer IT-related delays, which, in turn, are highly correlated with longer project delays. In addition, higher budget overruns are associated with greater design change and project delays. Not surprisingly, an inverse relationship exists between the magnitude of design change and user acceptance of the redesigned process.

Table 12: Bivariate correlations among end-stage design change and select project success measures.

	Process Design Change	IT Design Change	IT-Related Delay	Project Delay	Budget Overrun	User Acceptance
Process Design Change	1.000					
IT Design Change	.211 (.020)	1.000				
IT-related Delay	.278 (.002)	.603 (.000)	1.000			
Project Delay	.196 (.320)	.429 (.000)	.826 (.000)	1.000		
Budget Overrun	.666 (.000)	.436 (.000)	.383 (.000)	.297 (.001)	1.000	
User Acceptance	−.463 (.000)	−.394 (.000)	−.321 (.001)	−.231 (.016)	−.343 (.000)	1.000

Note: Level of significance is in parentheses.

DISCUSSION

Our findings indicate that endogenous adaptation is more effective when the major adaptive decisions are properly aligned. In other words, engineering decisions can be implemented more effectively when administrative decisions complement entrepreneurial decisions. For process redesign projects, the primary engineering decision concerns the design of the new work process. A salient and highly pragmatic measure of an adaptive cycle's internal effectiveness is the extent to which the initial design must be modified to complete its implementation. Our hypotheses suggest combinations of adaptive decisions that are most effective in minimizing end-stage design change, and our results support the predicted hypotheses. To summarize our empirical findings, IT-enabled work process end-stage design change is minimized when first movers use synoptic planning (H1), late adopters use adaptive planning (H2), and early adopters use aspects of both planning modes (H3).

Taken together, these findings provide two new insights for the adaptation literature: how the nature of process-platform design uncertainty differs with strategic type and how entrepreneurial and administrative decisions affect resolution of the engineering problem.

Process-Platform Design Uncertainties Faced by Strategic Types

As first movers, the design uncertainty faced by *prospectors* involves the patterning of novel process activities and IT support. This type of design uncertainty is best resolved through comprehensive planning, which is characteristic of a synoptic approach. As late adopters, *defenders* confront much less process-platform design uncertainty because they are replicating a proven process. The primary uncertainty defenders face is in systems integration. With an emphasis on maintaining markets through cost efficiency, they seek process improvement with minimal disruption to their technical core. Their risks are minimized through incremental change, characteristic of adaptive planning. As early adopters, *analyzers* face considerable uncertainty in process-platform design due to limitations regarding what can be learned from first mover design experiences. Analyzers also face integration issues, but are more willing to disrupt operations than are defenders for a competitive gain. A mixed planning mode that permits IT investments based on a comprehensive requirements analysis coupled with implementation based on feedback-driven adjustment proved most effective for early adopters.

Resolution of the Engineering Problem

First movers face more uncertainty surrounding process-platform design than do early and late adopters. The earlier problematic issues can be surfaced and accounted for in both the new work process and the enabling IT platform, the more viable is the process–platform relationship. A comprehensive, systematic approach to planning allows for the robust synchronization of IT capabilities with process requirements in formulating a blueprint for design. As postulated, first movers that relied on adaptive planning were confronted with more extensive end-stage design changes than those that relied on synoptic planning. In particular, a thorough assessment of the IT capabilities required by the new work process requirements permits an accumulation of IT artifacts and knowledge prior to when they are needed; modifying the IT platform in anticipation of process requirements sets a trajectory for process design. Our data suggest it is the early specification of a novel design that significantly improves its chances for success.

Organizations undertaking innovative IT-enabled work process redesign initiatives (i.e., first movers) are thus advised to invest considerable time and effort in the initiatives' early design stage. As nonintuitive as it might seem, the less that is known about the intended process–platform context, the more detailed and complete must be the initial design specification. By laying out the process–platform design in detail, the planning team is essentially forcing the surfacing of problematic issues, that is, the team discovers what it does not know, and it searches for resolutions to problems *before* implementation physically begins. Who should be involved with this early design stage planning effort? Ideally, a cross-disciplinary team knowledgeable about the work process, the business objectives being sought, the business contexts in which the work process is to be implemented, work process design, IT architecture, the IT assets to be accessed or affected, and the platform technologies to be applied. The more knowledgeable this team, the more issues will be surfaced and the more robust will be the initial plan. When should this planning stage end? We suggest that this planning effort terminate only when the rate that problematic issues are surfaced significantly declines.

For late adopters, far less uncertainty characterizes the process design initiative as experiences of prior adopters can serve to guide the initial process–platform design. As a consequence, far less attention and effort are needed for the early design stage than for first movers. Essentially, a small core team knowledgeable about the work process, the business objectives for the initiative, the work process context, and the platform technology need only seek out an existing design that has proven successful in similar environments and then organize the subsequent implementation project (applying proven project management practices).

Instead of being targeted at the early-stage design phase, the core project teams' attention and effort shift to allowing the initial design to be adapted as needed to the process context and situation as implementation transpires. Feedback-driven adjustments provide late adopters the flexibility needed to respond to emerging conditions and the control to maintain operational efficiencies. In fact, too tight up-front process–platform specifications can lock late adopters into predefined IT capabilities that may prove inadequate or inappropriate in meeting work process needs, thus engendering major workflow modifications and radical changes in the nature of IT support for workflows. To enable these feedback-driven adjustments, the small core project team must develop and maintain active linkages with process design and IT experts so that these knowledge sources can be accessed and tapped as workflow issues arise during implementation.

Early adopters are presented with perhaps the most challenging and potentially the most rewarding situation. While they can learn from first movers, simply replicating the success of first movers does not enable early adopters to effectively leverage the experiences of first movers. Considerable uncertainty remains for early adopters, with the learning that has occurred being limited to the specific contexts exposed by the first movers. Early adopters thus must account for firm-specific idiosyncrasies through careful early-stage process design planning. Then, by serially deploying IT resources based on successive feedback, early adopters can integrate others' learning with their own learning, thus making the most of available knowledge and facilitating a controlled response to design uncertainties.

Early adopters, hence, are best served by a synoptic mode when formulating their plans, and later by an adaptive mode when implementing those plans. Early adopters are accordingly advised to invest heavily in both the early design stage (putting together a sufficiently large planning team to provide the requisite knowledge to fabricate a robust, comprehensive initial process design) and in an adaptive planning capability (providing a smaller core implementation team with active linkages to expertise sources such that these sources can be utilized as needed as the implementation unfolds).

CONCLUSION

In adapting to environmental conditions, organizations make a series of decisions regarding technology position, project planning, and technology and process design that together determine their ability to enact or change their surroundings. The ease with which this is done depends on the knowledge available to create a more predictable environment for change. In the context of endogenous adaptations like process redesign, the alignment of technology position and planning mode has a profound effect on the engineering problem of end-stage design change. In order to minimize end-stage design change, the design uncertainty embedded in a technology position must be alleviated with the proper planning mode. As described above, our findings indicate that end-stage design change is minimized when first movers use a synoptic planning mode, when late adopters use an adaptive planning mode, and when early adopters use a mixed planning mode.

When management embarks on a program of change without considering the entrepreneurial, engineering, and administrative problems as interrelated aspects of an adaptive cycle, organization performance is likely to suffer. This has implications for practice and for future research examining adaptive change.

For practitioners converting to electronic work processes, an understanding of their internal process and technological environments (in particular, the necessity to tightly align and coordinate the work process and IT platform designs) is critical for effective organizational change. As complexity increases with interorganizational systems, such alignment is an essential factor for project success. Compatible adaptive decisions—prescribed earlier as resolutions to the engineering problem—can mitigate redesign impediments arising from end-stage design change. How that mitigation occurs is fruitful ground for further exploration.

For scholars studying adaptive change, incorporation of the engineering component of Miles and Snow's adaptive cycle is needed to understand the relationship between endogenous and exogenous adaptation, which affects organizational performance (Shortell & Zajac, 1990). Future research is also advocated that strives to understand how variance in adaptive decisions contributed to redesign failures. Thus, research involving Miles and Snow's fourth strategic type, reactors, is desirable, as it may provide opportunities to understand the consequences of shifts, over time, in adaptive decisions as well as the antecedents of such shifts.

Additional studies applying Miles and Snow's adaptive cycle to IT-enabled change would help overcome the limitations surrounding this study. Given Miles and Snow's assertion that business strategies are industry-specific (1978b), we limited our sampling population to hospitals that had introduced IT-enabled, process redesign initiatives. Although the redesign projects were diverse in character, industry factors such as regulatory requirements and accreditation guidelines may have mandated and restricted the types of redesign projects these hospitals undertook. Replication of this study in other contexts is needed to establish the reliability of Miles and Snow's adaptive cycle across endogenous adaptations. Also, in the hospital context, licensing pressures may have shortened implementation horizons; research is needed to understand the impact of implementation horizons on the adaptive cycle, particularly regarding planning mode effectiveness. Another limitation involves sampling bias, as the nature of projects included in this study may have differed from those that declined to participate. Finally, log-linear models also impose limitations. By collapsing data into polytomous variables, valuable information can be lost and the parameter estimates generated only indicate the likelihood that an outcome has occurred. The magnitude of the difference between likelihoods must be derived from antilogs, which are difficult to interpret for multiple interactions. Thus, we encourage others to explore these relationships with variable operationalizations enabling alternative analytical methods.

In conclusion, our findings provide new insights into how adaptive decisions can produce favorable and unfavorable end-stage design changes in IT-enabled organizational change initiatives. To effectively implement IT-enabled organizational change, firms must leverage their IT platform by carefully timing IT investments in accordance with the technology position adopted regarding work process change. Directing the design, development, and deployment of an IT platform so as to complement the firm's technology position reduces design uncertainty, thus promoting redesign success. Incongruent adaptive decisions will inevitably result in greater design uncertainty and implementation risk. By explicitly incorporating the engineering problem within studies of endogenous adaptation, we can begin to understand how firm performance can be constrained by the nature of the path by which organizational change unfolds. [Received: November 2005. Accepted: June 2006.]

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APPENDIX: MEASUREMENT SCALES

Telephone Interview and Survey Items—Project Manager

What is the most recent redesign project you have implemented (project name)?
What were the project's goals?
Describe the process before the redesign project was implemented.
Describe the intended work process.
Describe the final work process (if it differs from the intended process).
When did this project start?
What was the initial scheduled completion date?
What was the actual completion date?
What was the most critical IT-related delay experienced?
How long did this delay the project?
Was this delay anticipated? (why or why not)

Using the scale provided, please indicate the extent to which you agree or disagree with the following statements as they pertain to the redesign project.

	Strongly Disagree			Agree			Strongly Agree
Technology position items							
TP1. The process was redesigned in anticipation of future industry trends.	1	2	3	4	5	6	7
TP2. The process was redesigned to create a competitive advantage.	1	2	3	4	5	6	7
TP3. The redesigned process is a de facto industry standard.	1	2	3	4	5	6	7
TP4. The redesigned process is unique, no one else is using it.	1	2	3	4	5	6	7
TP5. This design was adopted because of its proven usefulness in the industry.	1	2	3	4	5	6	7
TP6. The redesigned process is a major departure from previous operations.	1	2	3	4	5	6	7
TP7. The redesigned process is similar to process designs used in other areas of our organization*.	1	2	3	4	5	6	7
Budget overrun item							
PP11. The project exceeded its budget.	1	2	3	4	5	6	7

*Due to its low factor loading, item TP7 was culled from the pilot survey.

Please indicate the response that best describes the extent to which the initial process design and intended IT platform design was changed to facilitate project completion.

Work Process Design Change

A. Minor changes were required to the initial redesigned process. New task skills or additional training to handle material and information flows were generally not required.

B. Major changes were required in one or more of the tasks embedded in the initial redesigned process; however, the flow of materials or information was not altered. New skills were required to accomplish the modified tasks.

C. Major changes were required in the flow of materials or information through the initial redesigned process; however, the tasks embedded in the intended design were not altered. Employees had to be educated regarding the new process flows.

D. Major changes were required in both the tasks embedded in the redesigned process and associated flows of material or information. New skills were required to accomplish the modified tasks and employees had to be educated regarding new process flows.

IT Manager Survey

Using the scale provided, please indicate the extent to which you agree or disagree with the following statements as they pertain to the redesign project.

	Strongly Disagree			Agree			Strongly Agree
Planning Mode Items							
PM1. Our organization has a formal IT plan.	1	2	3	4	5	6	7
PM2. The business unit had a formal redesign plan.	1	2	3	4	5	6	7
PM3. Business unit personnel were involved in IT planning.	1	2	3	4	5	6	7
PM4. IT personnel were involved in redesign planning.	1	2	3	4	5	6	7
PM5. Redesign goals were clear to IT personnel prior to process implementation.	1	2	3	4	5	6	7
PM6. The information and IT needs of the redesign project were considered when formulating the IT plan.	1	2	3	4	5	6	7
PM7. An assessment of IT capabilities and limitations was used in redesign planning.	1	2	3	4	5	6	7
PM8. Alterations to the IT platform were made as a specific project need arose.	1	2	3	4	5	6	7
PM9. Alterations to the IT platform were anticipated prior to process implementation.	1	2	3	4	5	6	7
User Acceptance Item							
PP2. The redesigned process has been accepted by its intended users.	1	2	3	4	5	6	7

Please indicate the response that best describes the extent to which the initial process design and intended IT platform design was changed to facilitate project completion.

IT Platform Design Change

A. Minor changes were required in the IT platform; new skills or additional training on the part of information systems personnel were not required.

B. Major changes were required in the components of the IT platform (hardware, software, data) without changing the platform's basic configuration. Components were changed in such a way that new knowledge was required on the part of information systems personnel to implement the change.

C. Major changes were required in the IT platform's configuration without significantly altering the components themselves. New skills and policies were needed to implement the change.

D. Major changes were required in one or more of the components making up the IT platform, as well as the relationships among components that altered the network's basic configuration.

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