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Abstract

Enterprise Resource Planning (ERP) systems present significant challenges to modern businesses. Although some organizations enjoy a smooth ERP implementation, others experience very public failures. The present research develops a general model that uses differences between **appropriability regimes** to predict which adoption strategies will lead to successful implementation. In strong appropriability regimes, intellectual property protection (e.g. patents) helps firms secure the benefits of technological innovation. However, ERP software is usually purchased rather than developed, so it is subject to the minimal intellectual property protection typical of a weak appropriability regime. It is the latter, weak appropriation context that is the focus of this study. A representative sample of 60 firms drawn from the Fortune 1000 that had recently adopted Enterprise Resource Planning (ERP) systems was used to test a model of weak appropriation with significant results. *Leadership* (social learning theory), *business process reengineering* (change the company not the technology) and *acquisition strategy* (buy, don't make) were found to be significant predictors of *adoption performance* (final model R-square=43%, F=5.5, p<.001, df=7,52). Industry (manufacturing versus service) and scale (sales) were included as control variables but were not significant in the analysis. *EDI* (electronic data interchange usage), and *project start date* were also used as control variables and were found to have significant regression coefficients. That is, EDI tends to substitute for, and slow adoption of ERP, and early movers finish implementation sooner than competitors. In general, strong, hands-on leadership, and business process reengineering coupled with purchasing ERP systems were found to be a much more effective adaptation strategy than tailoring enterprise software. The implications of these results are discussed.

The Adoption of Enterprise Resource Planning (ERP) Systems

Most R&D resources are allocated to developing new products and services. In contrast, process technologies and new information systems are usually purchased from suppliers. These two facts, taken together, suggest that most organizations simultaneously use strong and contend with weak appropriability regimes when attempting to capture benefits from new technology investments. A strong appropriability regime describes an environment with significant protection for innovations, whereas a weak regime offers little protection for these new products or processes. Many interesting questions remain concerning strong regimes of appropriation, including patent reform, intellectual property rights of inventors, the use of platforms in new product development, and spending on basic research and science education (e.g., Carey, 1999). Recent trends suggest that the instances of weak appropriation context are increasing while some strong appropriation conditions are weakening.[2]

In this study, the issues of weak appropriation context are explored and a model is developed and tested that explains alternative ways of strengthening weak regimes. Specifically, this study will examine the adoption of process and information technologies supplied from outside the organization. Many of these purchased systems are computer-assisted technologies used to promote integration in organizations, but they have demonstrated wide variance in outcomes and performance. Although organizations appear to confront similar challenges in changing their externally sourced technologies, significant outcome disparity generally results. How can the same adopted technologies generate such an array of different appropriation consequences? This is the research question of the current study.

The context chosen for this research is the adoption of enterprise resource planning (ERP) systems, which involves large purchases of computer software and often requires new hardware technologies, as well. The cost of a new ERP system runs from $50 million to $500 million or more, depending upon size of the organization and system options selected (Davenport, 1998). U.S. companies spend about $250 billion annually on computer technology, yet one survey found that 42% of corporate information technology projects are terminated before

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[2] Traditional methods of protecting inventions often fail to create strong appropriability (Joly and de Looze, 1996). The effectiveness of patents relative to other mechanisms of protecting intellectual capital property has not increased since the 1980's (Cohen, Nelson and Walsh, 1997). Backward vertical integration does not always provide lower cost (Fronmueller and Reed, 1996) and it is often not possible to vertically integrate operations (Teece, 1998). Use of alliances is growing (Osborn and Hagedoorn, 1997), and those involving technology considerations raise appropriation issues (Gulati and Singh, 1998). Further, the investments in adopted process and information technologies are huge and escalating, perhaps because these innovations enable vertical integration without ownership (Schmitz, Frankel, and Frayer, 1995).

completion (Wysocki, 1998).[3] Many of these massive investments in computer technology are coincident with business process reengineering[4] but these projects fail to meet their objectives in 50% to 70% of the cases documented (Stewart, 1993; Roth and Marucheck, 1994; Rohleder and Silver, 1997). Bad software, alone, cost U.S. companies $85 billion (not million) in lost productivity in 1998 (Gross, Stepanek, Port and Carey, 1999). It appears that the more radical the change being attempted, the higher the failure rate.

In spite of the risks involved, the quest for better performance using computer technology continues. In the auto industry alone, it is estimated that more extensive use of electronic data interchange (EDI)[5] between suppliers and original equipment companies could save $1.1 billion or about $71 per car. Although EDI is a popular way to establish electronic integration within and between firms, one of the important emerging technological interventions used to guide investments in new computer system is enterprise integration. Also called enterprise resource planning (ERP), this technology includes "...programs that can manage all of a corporation's internal operations in a single powerful network."[6] ERP can help organizations to standardize their information systems in order to avoid the high cost of multiple hardware-software systems' maintenance.

For example, Owens-Corning, which was in the process of installing a SAP, Inc. enterprise-wide information system, expects to avoid an annual expense of $35 million in information system maintenance with this new technology (White, Clark and Ascarelli, 1997). Owens-Corning started by redefining their markets to be global and broader than just insulation in an attempt to increase the proportion of materials they supplied in a typical building like a residential home. Another example is General Motors Corporation which estimates they are

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[3] In order to put this statistic in perspective, over a dozen studies have reported the nearly identical failure rate, about 40%, for new products after they have been introduced (Crawford, 1987; Power, et al, 1993).
[4] "Throughout our discussion, the terms Business Process Redesign and Business Process Reengineering (BPR) are used interchangeably referring to *the critical analysis and radical redesign of existing business process to achieve breakthrough improvements in performance measures*," Teng, Grover, Fielder (1994)
[5] "In the 1970's and 1980's, businesses extended their computing power beyond the company's walls sending and receiving purchase orders, invoices, and shipping notifications electronically via EDI (Electronic Data Interchange). EDI is a standard for compiling and transmitting information between computers, often over private communications networks called value added networks (VANs)," U.S. Department of Commerce, "The Emerging Digital Economy," April, 1998, p. 12,
[6] Stephen Baker, "SAP's Expanding Universe," Business Week, September 14, 1998, 168, 170. The market for enterprise software is now dominated by SAP and is estimated to be about $12 billion per year, and if installation is included, this rises to about $30 billion. What is ERP? "An Enterprise Resource Planning system is a packaged business software system that allows a company to: automate and integrate the majority of business processes; share common data and practices across the entire enterprise; and produce and access information in a real-time environment," Deloitte & Touche, "ERP's Second Wave: Maximizing the Value of ERP-Enabled Processes," Deloitte & Touche Consulting LLC, 1998.

saving $400 million a year after information systems were integrated. Finance alone at GM had 1,800 systems of which 70% are scheduled to disappear (Jackson, 1998).

In this paper it is argued that enterprise integration, which is a technological intervention designed to achieve better coordination, is an example of what economists call the "appropriation of rents" problem. That is, since the bulk of enterprise technology systems (like other process technology) are now supplied rather than developed internally by organizations, it is very challenging to capture the benefits of these investments. Organizations tend to invest R&D in new products and services, not new process technology (Wolff, 1994). Any purchased technology is theoretically available to all organizations—including competitors (Teece, 1988; 2000). Further, because of the popularity of these new hardware-software systems[7], all customers are now competing for the scarce resources of supplier attention, since there are only a handful of companies that can provide this technology. Consulting companies do take up some of the short-fall by providing the temporary labor and advice needed to plan and implement these systems. However, consultants learn from their hosts and sell their accumulated knowledge to the next client, further eroding the innovator's proposed advantage. Therefore, the appropriation or capture of benefits from innovating in this way becomes an even more difficult challenge than securing returns from a new product or service technology.

Anecdotal reports indicate considerable variance in success with enterprise integration programs (White, et al, 1997; Baker, 1998). Hershey Foods Corporation was recently estimated to have lost $100 million when a new computer system designed to integrate every thing from taking orders to loading trucks did not come on line as planned just as Halloween orders were coming in. The "business process transformation under way at Hershey is an enormously complex undertaking," and the problem was not with the software but with the "big bang" approach used for adoption (Nelson and Ramstad, 1999, p. A1). Whirlpool experienced similar problems at a time when orders were escalating which has delayed shipments to many distributors and retailers. Allied Waste Industries and Waste Management, Inc. have both recently cancelled ERP installations originally estimated to have cost in excess of $100 and $200 million, respectively (Boudette, 1999). This appears to be a fertile context in which to investigate the more general research question: *how do we account for the differences in outcomes of adoption of new process technology designed to intervene and promote coordination, e.g., enterprise resource planning systems?*[8]

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[7] Baker, Ibid., SAP grew at a rate of 66% in the first half of 1998.
[8] The same question could be asked and investigated for EDI, computer-aided design (CAD), and any number of other technological interventions designed to promote integration (e.g., tight coupling).

In order to offer a new perspective on this question, a general model is developed which predicts a contingency relationship between appropriation conditions (weak vs. strong) and adaptation strategy (change the organization versus change the technology). To apply this model to the specific case of ERP, the general model can be extended to include other factors. Three classes of variables are tested and subsequently shown to significantly influence the early stages of appropriation of the benefits (i.e., adoption performance) of ERP in large U.S. companies: *leadership* (social learning theory), *adaptation strategy* (business process reengineering), and *technology acquisition strategy* (make/buy decisions). General managers who actively use and manage ERP deployment are the most successful. Business process reengineering coupled with purchasing ERP systems was found to be significantly more effective as an adaptation strategy than tailoring software coupled with training. Results persist when controlled by scale of operations, industry, electronic data interchange (EDI) and start date. The implications of these results are important for planning and configuring technologies designed to integrate organizations.

Weak versus Strong Appropriation Conditions

Appropriation issues, or conditions of benefit capture from investments, are embedded, for the most part, in transactions cost economics (TCE) theory (Coase, 1937; Williamson, 1975). Economists classify the appropriation conditions according to the commercial environment, excluding firm and market structure, that influence the degree to which an innovator can capture innovation rents or benefits (Teece, 1988, 1998; 2000). Among the most important conditions affecting regimes are the technology itself and efficiency of legal mechanisms for protecting innovation such as patents and trade secrets. Since contracts are often difficult to enforce, vertical integration is one of the few alternatives available when appropriation conditions are weak. For example, vertical integration is preferred over market exchanges, e.g., with suppliers, when transactions are complex and when both buyer and seller must invest in specific assets. Human assets and investments in engineering effort have been found to be more important than physical assets in predicting backward, vertical integration (Monteverde and Teece, 1982; Masten, et al, 1989).

Although the empirical evidence to date has been generally supportive of TCE, concerning organizational choices that have been made, it "provides, at best, only limited

evidence regarding the value of the theory as a basis for managerial prescriptions," Masten (1993, p. 120). Further, it is not always possible to vertically integrate or establish an alliance. Therefore, a blending of economic and governance theory, the latter having an orientation towards benefit performance as opposed to cost performance, is warranted. It is also possible to model weak appropriation using constructs that transcend governance (e.g., strategy and structure) issues with other constructs such as leadership. Further, appropriation has generally been conceptualized and tested indirectly, e.g., with vertical integration studies. An alternative to this method would be to study this phenomenon directly and find proxy measures of appropriation.

Adaptation Strategy and Appropriation Conditions

The implications of appropriation conditions for adaptation strategy are quite important. Based on the literature cited above and elsewhere (e.g., Caballero and Hammour, 1998), one can begin to fit a model to the data on development and adoption (purchased) of new technology projects which involves contingencies associated with appropriation potential. For example, Ettlie (1997) found that new product introduction success was partly but significantly enhanced by tailoring computer-aided design (CAD) software to company needs. On the other hand, most normative literature on ERP adoption (e.g., Davenport, 1998) strongly recommends business process reengineering be done first or at least in conjunction with installation of new information technology. This same literature on ERP and business process reengineering (BPR) uses two general categories of adaptation strategy: change the organization to fit the software or change the software to fit the organization. A third, and obvious hybrid strategy is to do both. However, since most ERP systems are purchased today, changing or developing the software is a rare strategy. It is usually a matter of degree rather than type.

Nonetheless, the general model that emerges from this literature depicts ideal types of adaptation (change the organization versus change the technology) and appropriation conditions (weak versus strong). This model is summarized in Fig. 1 below. Predictions about the potential outcomes of ERP adoption are function of these contingencies and they are discussed.

Figure 1

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Weak Appropiability Regime/Change Organization. The first high performance condition in this model of adaptation is one that is typical of the normative literature in this field. If you automate a business process without changing the organization, errors will just be produced faster after upgrading the software (Hammer and Champy, 1993). Empirical evidence from other technology adoption situations agrees. Ettlie and Reza (1992) found that significant organizational changes were required in order to capture the benefits of new manufacturing technology. Old organizational strategies and structures simply did not work. Therefore, it was predicted that the most effective adaptation strategy for weak appropriation conditions (e.g., ERP adoption) is to change the organization (e.g., effective business process reengineering).

Strong Appropiability Regime/Change Technology. The second high performance outcome prediction is made in this model for the strong appropriation condition coupled with changing the technology to fit the organization. This is quite natural when the core technologies of an organization are exploited to enhance new products and services that can be protected under such laws as patents and copyrights. One exception to this rule is the introduction of disruptive technology (Christensen, 1997) somewhere in the domain of the firm (with a unit, by a partner or by a competitor). A second exception is when the core business is a process or information technology like suppliers of software or pulp and paper-makers. But these situations are equivalent to purchasing technology for this model because new technical ideas have to be imported to the mainstream of the firm.

Strong Appropriability Regime/Change Organization. The first of the "mixed results" predicted conditions in the model occurs when an organization has the clear rights to a technology but needs to significantly adapt the organization to exploit these rights. This can occur under a number of circumstances. For example, when a firm has a new product technology but has not built up the processing or delivery technology to successfully launch the new idea. It can also occur when a firm has too many good ideas and technologies to exploit— the implementing organizational units are not there or the technology transfer function is weak. IBM recently reorganized its R&D function to become more focused and decentralized to over come this challenge (i.e. they changed the organization). This involved dropping some basic R&D lines of inquiry such as neutrino science, but the reorganization has paid off (Ziegler, 1997).

IBM, however, was the exception to the model. This condition of changing the organization in order to exploit a strong appropriability condition is a mismatch of adaptation and usually results in mixed outcomes (some positive, some negative). Expending heroic effort to capture benefits from a technology that is already yours defeats the purpose and gives competitors the advantage.

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Weak Appropriability Regime/Change Technology. This adaptation approach may be the most challenging for any company. Not only are the rights to the technology restricted, an organization may choose to try and change this technology to fit its needs. This strategy is doomed to failure for the simple reason that the resources and willpower needed to change this much in an organization's domain are usually beyond its capability. It may also be a misguided goal. The technology often represents practice that supercedes the organization's current best efforts. To attempt to change this technology often results in seeking a lower common denominator. In addition, this strategy plays into the hands of political forces within the firm that oppose change because the standards for outcomes are not clear.

Having specified this general model, the details of adaptation strategies are introduced next using on the weak appropriation condition. First leadership, then goal structure and then acquisition strategy (make/buy and business process reengineering) are taken up.

Organizational Learning and Weak Appropriation

In spite of the large and growing literature on organizational learning, little has been published on how to introduce learning in the workplace (Lipshitz, Popper and Oz, 1996). Two types of learning have been identified: trial and error, or learning by doing, and observation, or learning vicariously. Most people think of the first and ignore the second, but observational learning is much more important when discontinuous change occurs. A person cannot rehearse a behavior that has not been at least partially acquired. During discontinuous change, there is no precedent and thus trial and error (on-the-job training) learning is not theoretically possible. Especially under weak appropriation conditions, when technology is typically imported from outside the organization, the necessity for observational learning is heightened because there are few or no internally capable persons to practice the art (Sims and Manz, 1982; Manz and Sims, 1981). Add the dimension of new technology and, especially, discontinuous change, which requires many unprecedented actions and decisions for success, and social learning and attendant theory of vicarious behavior acquisition (Bandura, 1977) becomes very important.

Leadership, Social Learning Theory and Discontinuous Change

Social learning theory has great potential application in understanding the role of leadership in discontinuous change. If behaviors are unprecedented, they need to be invented or demonstrated. Just providing verbal direction or vision will not be sufficient in this situation. This is the notion of 'walking the talk,' or exemplary action (Steyrer, 1998). Senior managers,

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especially, need to model the behaviors necessary for the entire organization to emulate. This becomes self-reinforcing for managerial efficacy (Wood and Bandura, 1989).

Early research on social learning theory and technology transfer demonstrated the importance of observational learning during episodes of discontinuous change (Ettlie and Rubenstein, 1980). These results and other theories suggest that leaders should coach as well as articulate vision (Popper and Lipshitz, 1992). In applying the social learning theory to leadership of discontinuous change, the actions of just one general manager will not be sufficient. Rather, the complexity and magnitude of change will require a more unified front approach to this intervention. The leaders' demonstration of concern for member welfare can have a powerful impact on employee self-efficacy (Shea, 1999). Karahanna, Straub and Chervany (1999) report that pre-adoption attitudes of employees are determined primarily by normative pressures, and post-adoption attitudes are based almost exclusively on beliefs of usefulness and image enhancement. Yet, most senior managers report considerable angst over the explosion of information technology (Veiga and Dechant, 1997). Therefore the following hypothesis is offered for testing.

Hypothesis 1: Leadership through exemplary action promotes the successful adoption of discontinuous change, especially when adopting firm general managers demonstrate a cohesive front of support vis-a-vis the new technology.

The rationale for this hypothesis is based on the social learning theory interpretation of the leadership behaviors required during discontinuous change and weak appropriation conditions, e.g., the adoption of ERP systems. Exemplary modeling of action is the key leadership behavior, consistently demonstrated by the management team, especially when the technology is unprecedented and sourced external to the firm that makes the difference here. Successful senior managers have to live the vision when radical change is adopted.

Adaptation Strategy: Business Process Reengineering

What is the appropriate strategy for deployment of large, new technology systems, adopted from suppliers primarily outside the firm? There are a number ways of answering this question, depending upon which part of a company's strategy is examined. At the highest level, the question becomes to what extent new technology adoption will change corporate (business

choice) or business unit strategy (competitive strategy). An important corollary to this question is whether strategic alliances will be a part of this acquisition plan?

Significant organizational change accompanies significant process change in successful plant modernization programs (Ettlie and Reza, 1992). Companies have generally ignored customer requirements in business process reengineering, or they have applied the wrong technology for change, and have not understood the value-added contribution of every business process (Guimaraes, 1997).

In the general model summarized in Figure 1 above, tailoring systems to meet the requirements of an organization under weak appropriation conditions is counterproductive for two important reasons. First, it is costly, and benefits under weak conditions are less likely to be forthcoming and second, it tends to maintain status quo within an organization rather than promote change to meet future needs. Hypothesis two is offered for testing.

Hypothesis 2: Successful capture of benefits from purchased technology results from changing the organization (e.g., business process reengineering) to leverage internal strengths for the future of the firm. Attempting to maintain the status quo of an organization, while changing the technology is counterproductive under weak appropriation conditions.

The typical information system adoption through outsourcing has been driven by cost reduction (DiRamualdo and Gurbaxani, 1998; Earl, 1996) but successful adoption of the best state-of-the art system, usually requires organizational change to capture benefits (e.g., more added value to customers). In the case of ERP adoption, this adaptation strategy takes the form of business process reengineering (Davenport, 1998).

Technology Acquisition Strategy

Scholars investigating appropriation of rents have typically framed this theory and empirical testing using vertical integration as the focus. In general, firms integrate backward when their engineering effort is high in a core technology (Masten, Meehan and Snyder, 1989). However, there are two limitations of this approach. First, appropriation is not directly conceived or measured using this method. Second, vertical integration patterns, or make-buy decisions are far too simplistic to capture all the sourcing alternatives available to organizations when exploring market versus hierarchy costs. Further, options and benefits streams are rarely

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considered in this research. Alternatives to vertical integration and innovations like information systems and new technology used to reduce transactions costs and boundary-spanning activities are needed to supplement this theory.

More recent trends in ERP adoption have been away from single source suppliers and toward best-of-breed mixtures of several suppliers, including global and local vendors (Hecht, 1997; Klotz and Chatterjee, 1995; Papanastassiou and Pearce, 1997). These trends suggest a refinement of outsourcing strategy, and more careful integration of information goals and strategic goals. Many ERP systems now include supplier and customer integration along with integration of internal operations (Zielke and Pohl, 1996). Therefore, without clear focus on core technology (typically new products and services), efforts to deploy complex, new adopted technology systems are likely to be very unproductive. Possible exceptions to this argument are companies that are also in the business of selling these process or information systems like the ERP suppliers. For example, Oracle Corporation recently installed their own ERP system (Hamm, Greene and Rocks, 2000).

The second part of this argument, and consistent with the general model summarized in Figure 1, is the purchased information technology needs to be coupled with successful business process reengineering (Hypothesis 2). The rationale for this idea was presented earlier, but to reinforce this view, under weak appropriation conditions of purchased technology, the most efficient approach to adaptation, as painful as it might seem at first, is to focus on changing the organization. Business process reengineering represents major organization change, but is the necessary step for success.

Hypothesis 3: Successful acquisition strategy for process technologies is likely to be dominated by purchase of "off the shelf" systems rather than internally developed, proprietary systems or tailored systems, either purchased or developed internally.

The rationale for this hypothesis is that for most organizations, process technology of operations, such as computer systems, is not part of their core technology supporting products and services. Most R&D is spent on new products and services, so the typical acquisition strategy that best utilizes scarce innovation resources is dominated by purchase of existing or tailored systems rather than internal development (make) alternatives. The more companies source standard modules and tailored systems rather than developing their own technology, more successful they will be. This allows the firm to continue to focus organizational change using business process reengineering, and to concentrate R&D resources on new products and services.

Adoption Performance Derived

In this section, we develop the dependent variable in this study, adoption performance, which is defined as the degree of success of a technological innovation by an adopting firm or unit, after system purchase. The context of the study is the adoption of an enterprise resource planning (ERP) system. Adoption performance is not conceptually the same as ultimate strategic success (Davenport, 1998) or operational performance (McAfee, 2002), but is expected to be a good predictor of both of these more ultimate measures of success.

The dependent variable in the innovation studies literature has almost always been problematic. The field has struggled with a definition of innovation for many years, and then settled on commercialized inventions as the de-facto standard (Ettlie, 2000). Diffusion of innovation, returns on investment in innovation, R&D productivity, flexibility, communication and technology transfer effectiveness have all been used as dependent variables, just to name a few. Whether an innovation is institutionalized or discontinued (Angle and Van de Ven, 1989) seems far too simplistic a way of characterizing success and failure of the innovation process but many authors continue to characterize technology and ERP in this way (Davenport, 1998; Nelson and Ramstad, 1999; Trunick, 1999; Capron, et al, 1995). In fact, many projects never end.

For our purposes, we distinguish between those innovations primarily developed and that operate under strong appropriation conditions and those innovations, which are adopted (purchased) and operate under weak appropriation conditions (Teece, 1988; Teece, 2000; Gilbert, 1995). We assume that no measurable performance or outcome behavior can be directly observed until adoption or initial commitment (in the case where the transaction is not economic) occurs. We assume that for ERP systems, purchase agreements are made and an economic transaction occurs. Then the question becomes at what stage of the process does measurement of results become feasible? Angle and Van de Ven (1989, p. 692) found that novelty seems to be correlated with overlapping stages in the process and more difficulty in capturing success measures.

Time dependency and temporal patterns are representative of much of the innovation literature (Rogers, 1962; Angle and Van de Ven, 1989, p. 693; Gopalakrishnan and Damanpour, 1997). Stage models of the adoption process continue to be the underpinning of much of the innovation research, including information technology deployment (e.g., Wildemuth, 1992; George, Nunamaker and Valacich, 1992), and for advanced manufacturing technology (Zairi, 1992).

Ettlie and Vellenga (1979) used inter-stage time lag (a total of 5 stages were used, including the last which was time lag from adoption to implementation) as the dependent variable in a study of 32 transportation innovations. They found that the best predictor (R-square=23%) of the amount of time required to progress from one stage to the next in the adoption process was cost—that is the more costly the innovation to the adopting unit the longer it took to decide to adopt and implement the change. This result has been subsequently replicated and extended (e.g., Germain, 1996; Rai and Patnayakuni, 1996; Premkumar, Ramamurthy, and Crum, 1997; Chau and Tam, 2000; Lai and Guynes, 1997) including time to implement for ERP systems (Kochan, 1999; Krumbiede and Jordon, 2000).

Similar to the new product introduction literature, cost is often expressed more accurately as value (cost versus perceived benefits) of adoption (Smith, 2000). That is, there is a clear and direct logical linkage between adoption performance and eventual business success. Cost theory (Williamson, 1975; Olk and Young, 1997; Shrader, 2001; Anderson, Glenn and Sedatole, 2000; Ngwenyama and Bryson, 1999; Argyres, 1996) forms a central linkage between the dependent variable of this study and ultimate strategic or operational outcomes. That is, adopted operational or information technology systems almost always have targets for reducing costs incorporated in their investment justifications.

Goal setting theory (Locke and Latham, 1990; Umstot, Mitchell and Bell, 1978; Klein, et al, 1999; Hollensbe and Guthrie, 2000; Weldon and Yun, 2000; Gambill, Clark and Wilkes, 2000; Brett and VandeWalle, 1999; Jessup and Stahelski, 1999; Abdel-Hamid, Sengupta, and Swett, 1999; Baccarini, 1999; Gollwitzer, 1999; Fowles and Edwards, 1999) is considered to be a prime candidate to form a conceptual link between adoption performance and ultimate strategic or operational outcomes with ERP usage. The rationale for this is both the consistent empirical findings showing the importance of goal setting in achieving performance outcomes and the conceptual link between deciding to adopt with justification and ultimate performance of purchased technology.

Implementation has typically been considered and studied as unique from adoption, primarily because incremental innovations become more structured and stabilized in their patterns as time passes (Angle and Van de Ven, 1989, p. 693; Yin, 1979; Shaw ,1999; Ettlie, 1980; Linton and Cook, 1998; Koehler, 1998; Kassapoglou, 2000). Rate of adoption and subsequent diffusion patterns have nearly always appeared as important in the innovation literature (e.g., Nabseth and Ray, 1974; Parkinson and Avlonitis, 1986).

However, there is an alternative view, which involves dividing the innovation process into two, rather broad phases: initiation and adaptation (sustaining) such as the early work by

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Ross (1974). This broad, brushstroke approach is still quite popular (Maansaari and Ilvari, 1996; Dekiple, Parker and Sarvary; 2000) and has held up well in validation studies (Gauvin and Sinha, 1993). However, the most compelling conceptual reason to use adoption performance over implementation success is that information technology has a "work-in-process" facet as a characteristic phenomenon. For example, concern over better options just now becoming available on the Internet are quite frequent (e.g. McNurlin, 2001; Neef, 2000). It is difficult to contend that implementation success is a concept with high content validity because of the continuing "unfinished" or the chronic "continuous improvement" aspect of the phenomenon. The real potential benefit of an ERP system is that it avoids significant costs in the typical company (Cavaye, 1996; Glover, Prawitt, and Romney, 1999). This savings is well documented in such sectors as the chemical processing industry through inventory reduction (Hairston and Chowdhury, 1999).

What is ultimately proposed here to reconcile these two approaches is an extension of the second alternative to understanding adoption. That is, for our purposes (the capture of innovation rents under weak appropriation), adoption and implementation are one in the same because they involve the same underlying causal process. In addition, we exploit the temporal nature of the innovation process in deriving two measures of adoption performance: 1. degree of accomplishment after purchase relative to competitors and 2. budget performance. Again, we emphasize that this is neither the ultimate strategic or business performance of the enterprise nor is it a substitute for operational performance, but rather an interim measure of innovation success for purchased technology. It is a unique construct which warrants separate attention.

There is already some evidence that conditions and factors associated with initial adoption of an innovation predict continued use such as for adopters of on-line services that eventually discontinue their use are different at the time of adoption that those people who continue use (Parthasarathy and Bhattacherjee, 1998). Innovative behaviors consistent with corporate strategies tend to be successful, regardless of stage of adoption (Congden and Schroeder, 1996; Butler, Coates, Pike, Price and Turner, 1996; Nijssen and Frambach, 2000; King and Kugler, 2000), which suggests little conceptual difference between adoption performance and implementation.

Cost theory and goal setting theory, as summarized above, are proposed as the key linkages between ERP implementation behavior and ultimate strategic business outcomes. It follows that measuring adoption performance with budget progress and implementation milestones relative to competitors has strong face validity. This method does not allow a direct

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comparison of actual goals against performance of individual systems in organizations, but goal migration was tracked in the data collection[9]. This is discussed next.

Methodology

A mailed survey using a 2-page questionnaire[10] of large U.S. companies in the Fortune 1000 resulted in a representative sample of 60 companies that had recently adopted enterprise resource planning systems in 1998-9. Data collection was suspended in June of 1999. An earlier version of the questionnaire was pilot tested with six ERP adopting companies. Phone-screened respondents (chief information officers were the primary target group) were encouraged to mail, fax or record answers on a web page. Because the usable response rate was only 6% (60 of 1000 returned complete with 10 responses thrown out), comparisons were made between an archive compiled on the Fortune 1000 and the sample.[11] No significant differences were found on earnings growth (t=1.2), employees (t=0.25), R&D (t=0.82), R&D percentage (t=0.79), ROE (t=1.19), and sales (t=0.88). However, the Fortune 1000 is approximately 40% manufacturing and 60% non-manufacturing, whereas type of responding firm distribution was just the opposite: 60% manufacturing and 40% non-manufacturing adopters of ERP systems. Industry was included as a control variable in regression analysis.

There are other indications of a very representative sample with low method variance. The distribution of ERP suppliers mentioned by survey respondents, who were primarily chief information officers or chief operating officers of their ERP adopting firms, was nearly the same as current market share distributions (e.g, SAP, Baan, Oracle, PeopleSoft, etc.).[12] For example, at the time of the survey, SAP currently held 32% of the market share of ERP systems (Boudette, 1999), and in this sample of 60 companies, SAP had 30% of the adoptions. Further, R&D

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[9] Some firms did change their goals during the course of their ERP project, a total of 11 of 60 cases (18.3%) but this change was not significantly correlated with the dependent variable, adoption performance (r=.258, p=.194, ns.)

[10] The questionnaire from the authors, and includes both structured and open-ended questions.

[11] This archive was compiled from Hoovers (http://www.hoovers.com/capsules/13494.html) and Lexus Nexus in the Michigan Business School Library computer files. Response rates have become a critical problem in business research, and single digit or small double-digit return rates have become typical. A comparable, 4-page questionnaire survey of APICS (American Production and Inventory Control Society) members on ERP adoption completed in September, 1999 by Professor Vince Mabert at Indiana University, produced a response rate of slightly less than 10% (479 of 5000). This was reported at the 6th Annual Midwest Manufacturing and Logistics Roundtable, Kelly School of Business, Indiana University, Bloomington, IN, October 23, 1999.

[12] See Claudia Deutsch, "Software that Can Make a Grown Company Cry," New York Times, November 8, 1998.

spending as a percentage of sales as reported and as shown in the computer files for the Fortune 1000 were very significantly correlated ($r = .87$, $p < .001$). We concluded that this was, indeed, a representative sample on on-going and completed ERP installations in large U.S. companies.

Adoption Performance

The dependent variable of the study was adoption performance or the degree of progress towards full-scale, successful implementation of the ERP system under investigation. The rationale for selection of this variable is twofold. First, acquiring data on adoption of ERP as it occurs is better than rationalized self-report data after systems are fully deployed. Second, it is assumed that the tournament model prevails in weak appropriation situations: early winners are the ultimate winners in new technology adoption. This rationale is a variant on the first-mover strategy. Two items on the questionnaire emerged from factor analysis of candidates for this scale: "What proportion of the project ($) is done?" (category responses were 10%, 25%, 50%, 75% and 100%); and "Relative to other companies in your industry, are you ahead, even or behind on project outcomes?" Factor analysis with principal components of these two items yielded a factor score of .85, communality=.73, and an eigenvalue =1.45, accounting for 72.6 percentage of variance in comparative, adoption performance. The intercorrelation of these two items was $r = .45$ ($p = .014$).

Validation of the Dependent Variable Measure

Two tests were performed in order to validate the dependent variable. In this triangulation of our results, if all three tests (original plus two validations) indicate the same pattern, it is likely that the dependent variable in the regression analysis is a robust representation that measures what it purports to measure.

First, a double-blind test was used with a panel of experts from the largest ERP system supplier in order to validate the dependent variable measure of adoption performance. A list of firms, which included the responding organizations and additional, randomly picked companies from the Fortune 1000, were given to a senior management representative of this supplier firm. Firms on this list (some were not in the sample) were subsequently evaluated by an expert panel from this ERP supplier firm, but only one score was assigned by the supplier firm and reported to the research team for each ERP adopting company. Experts on the panel were not told which firms were in the sample and which firms were picked randomly, but they did know there was a

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mix of companies in the evaluation set. Firms were gradually eliminated from this list if the supplier panel had no detailed knowledge of the ERP system being installed. The expert panel was asked to evaluate the state of progress of the ERP installation at any given company on the list using one of the same questions on the survey questionnaire: "Relative to other companies in that industry, is the firm ahead, even or behind on project outcomes?"

A total of 14 firms on the supplier list were also in the sample. These firms were scored by the panel of experts and also had evaluations from the respondents in the survey. Validation statistics were compiled separately by two research assistants independently, and the source of the scores and ratings was "blind" or unknown to each. In nine of the 14 cases (64%), there was perfect agreement in the category (ahead, even, or behind) chosen by the sample respondent and the panel of experts. In the remaining 5 cases (36%), the category choice was off by just one level, e.g., a case scored "ahead" on the survey, and "even" on the expert panel evaluation. Kendall's correlation for the rank-order association between the survey scores and supplier expert panel scores was tau b= .418, p= .061 (n=14). The Pearson r =.439, p=.058 (n=14).

The second validation test of the dependent variable was a review of recent journal and popular press articles about the ERP progress of the firms in the sample. The reviewer in this case was knowledgeable about Enterprise Systems, but was unaware of the rankings given to each firm in the regression analysis. As before, the reviewer sought to answer one question from the survey questionnaire: "Relative to other companies in that industry, is the firm ahead, even or behind on project outcomes?" Ratings of 3, 2 and 1 were assigned for ahead, even and behind respectively. This procedure is comparable to criterion validation used in psychological studies.[13]

Of the 60 firms in the sample, 27 were found to have relevant articles in the ABI/INFORM database since 1999. The reviewer rankings correlated significantly with the dependent variable with Pearson r=0.589 (p = .021). Because the larger firms were more likely to have press or journal articles in the database, a regression analysis was also run with the reviewer ranking and control variable firm sales as independent variables. In this case, firm sales were taken as a proxy measure of firm size. The reviewer rankings contributed significantly to the regression with Beta = .582, t = 2.271, p = .044. Firm sales did not contribute significantly to the regression with Beta = -.130, t = -.509, p = .620. This regression analysis indicates that the

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[13] Cf., J. Nunnally and I.H. Bernstein, Psychometric Theory, 3rd Edition, New York, McGraw-Hill, 1994, p. 94. In this reference, criterion-related validity is actually discussed as predictive validity, such as in the development of a test for college admission. Without good theoretical connections between predictors and criterion, however, the issue of construct validity or the "criterion problem" needs to be addressed. Here there is little issue with the test used since both involve ERP performance. Given the elapsed time used for this test, the strong correlation between these two outcome measures is important evidence of validity.

relationship between the reviewer rankings of subsequent press reports on ERP performance and the dependent variable was significant beyond the chance level controlling for firm size.

Given the confirmatory results of these two validation tests, the survey appears to have captured a robust and valid measure of comparative ERP adoption performance for this sample of larger U.S. companies. This dependent variable measure has high internal consistency as well as construct and predictive validity.

Leadership

We measured leadership as a social learning construct using a five-item scale which included answers that were coded from the following questions: 1) Whether or not all general managers used the new ERP system, hands-on (coded 1 for yes, and 0 for no)[14]; 2) whether or not quality was part of the ERP project (coded 1 for yes, 0 for no); 3) whether or not third parties were involved (and by implication managed) as part of the project (coded 1 for yes, 0 for no); 4) whether or not a focused strategy for adoption of ERP was evident, based on the coding of an open-ended question which asked, "What was the strategy for your ERP project? The responses were coded 3 for very focused, 2 for between-focused and diffuse and 1 for unfocused (e.g., conquer the world); and finally 5) a measure of focus in goals based on the standard deviation of the percentages assigned to goals for the project (i.e., cost reduction, customer response, new product introduction, Y2K (year Two Thousand), cycle time reduction, and global data integration), which scores $sd <= 15\%$ as 1 and $sd < 15\%$ as zero. For each coded item, the highest value indicated "more" leadership in the new scale. The Cronbach alpha for this five-item scale was 0.64 and the standardized item alpha was 0.66.

Adaptation Strategy: Business Process Reengineering

Our model calls for significant organizational innovation and change or major process technology adoption, and in this case, for the adoption of ERP, we predicted that business process reengineering (BPR) needed to be used. There was one, two-part item on the questionnaire related to BPR. The question reads as follows: "If business process reengineering was done, which process was reengineered." Space was provided for three responses. If at least one business process was listed, the item was scored 1 for yes and if it was blank it was scored 0 for

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no. We also investigated the order in which business process reengineering was done and found no significant trends. Future work should address this issue.

Acquisition Strategy

In order to gauge the acquisition strategy in this short questionnaire, one question was used: "Did you make (%), buy (%), or buy tailored (%) systems? (what proportions?)?." Respondents would then list off or indicate next to each acquisition option the proportion for each choice. By far the most popular choice was to buy the new information system (averaging 80% of the choices)

Control Variables

Several variables captured by items on the questionnaire were used as controls in the regression analysis. The **scale** of operations was measured by sales volume. **Industry** was a constructed variable from manufacturing (60% of the sample, coded "1") and nonmanufacturing (e.g., service, or 40% of the sample, coded "0") using SIC (Standard Industrial Classification) information on each firm. It should be recalled that the Fortune 1000 composition is just the reverse of this sample proportion: 60% service and 40% nonservice. ERP appears to be more popular among manufacturing firms. **EDI** (Electronic Data Interchange) usage has been reported as critical in separating efficient users of information technology (Deloitte & Touche, 1998; Hart and Saunders, 1997). Therefore, it was used as a control variable in the study. Data on EDI usage was obtained from one item on the questionnaire: "Do you use EDI (Electronic Data Interchange)?" Response categories were: "a. Yes (If Yes, how is it a part of this project?)" which was scored 1, and "b. No." which was scored 0. **Project start date** was included as the final control variable to establish a base line for comparison in the dependent variable.

Results

The correlation matrix, with descriptive statistics, and regression analysis summary appear in Tables 1 and 2 below respectively. The final regression model is detailed in Table 2.

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[14] The first item which conceptually was the best representative of the construct from a social learning perspective also achieved the highest corrected, item-total correlation of .56 which greatly enhances content validity of this scale.

Regression results are OLS (ordinary least squares) using mean substitute for missing data was used in this analysis. Correlations with and without mean substitution were compared and no significant differences were found.

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insert Table 1, 2 here

The overall regression equation is significant (F=5.54, p<.001, with 7,52 degrees of freedom), and accounts for 43% of the variance in the dependent variable (35% of the variance adjusted for degrees of freedom). Both standardized regression coefficients (beta) and unstandardized coefficients (b) and standard errors are reported in Table 2.

Results that are reported in the summary regression equation in Table 2 strongly support the three hypotheses of this study. Leadership, as measured by the five-item scale constructed here, was a very significant predictor of adoption performance in the regression equation, with beta= .357 (p=.002). **Business process reengineering** (beta= .267, p=.019) was also significantly related to adoption performance. These two results sustain the first two hypotheses. The third hypothesis was also strongly supported. **Acquisition strategy**, as represented by the percentage of systems purchased by the firm (**% buy**) is significantly and directly related to adoption performance (beta =.337, p=.006). Buying tailored systems percentages and making (writing own)[15] software do not enter this model.[16]

Two of the control variables were not statistically significant (sales, industry). On the other hand, both **EDI** usage (beta= -.268, p=.014), and **start date** (beta= -.257, p=.02) were significant predictors in the regression equation. The EDI result indicates that these firms are possibly somewhat behind in EDI adoption and are using ERP to complete many integration tasks. Alternatively, EDI takes the place or "substitutes" for at least part of what ERP can offer a firm. This EDI substitution effect warrants further research

The statistical significance of start date in the regression equation is easier to interpret. Firms that start early are further ahead in ERP installation. This could be interpreted as an early mover advantage, but that was not the focus of this research. The significance of this control

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[15] Although the "make" percentage does not enter this equation, it was inversely related to the dependent variable (r= -.355, p=.075, two-tailed test, n=26), consistent with these results.
[16] The interaction term of BPR x %Buy was checked in a regression with the other predictors and control variables and was found to be nonsignificant (Beta= -.389, t=-1.174, p=.246).

variable does not, in any way, diminish the other main effects in this model which are very robust.

Other Findings

Responses to open-ended questions revealed the three most common **unanticipated problems** reported by responding firms: 1) change in scope of the project during adoption; 2) insufficient training and preparation; and 3) disruption caused by personnel changes. The three most common **unanticipated benefits** were improved business processes, improved discipline and teamwork, and improved capacity for change and customer focus. Lessons learned included a new view of change management that did not blame employees for any failures of deployment, the increased need for education, training and development, and the importance of vision and management leadership. Most companies underestimated the time and cost to implement ERP and the extent of "package" issues involved.

A total of 26 of the 53 (49%) responding (7 missing cases) said that the **Internet** was part of their ERP adoption. Half of these ERP/Internet adopters were using cyberspace to service customers. Only 15% of Internet adopters were using it to link with suppliers and 12% were using the internet for internal purposes and link intranet with Internet applications. Internet usage was not significantly correlated with adoption performance ($r= -.06$, n.s.), or any of the other predictors in the model. This suggests that blending of the new and old economy in these firms continues to be challenging.

Discussion

When firms purchase new technology systems, they enter the world of weak appropriation conditions and are challenged to secure and protect any gains this technology might provide over competitors who often adopt the same new systems. The context for this study was enterprise resource planning (ERP) systems, an important example of adopted technology. For a sample of 60 large, U.S. companies, it was found that leadership, business process reengineering and acquisition strategy (don't make, but buy coupled with business process reengineering), were significant predictors of adoption performance. These results persist when controlling for industry, and scale of operations (i.e., sales). We discovered an "EDI substitution" effect in our control variable testing—firms that have already had EDI are slower to implement ERP systems, and companies without EDI are faster to embrace ERP. We also found, by controlling for start date, that early movers were ahead of competitors in ERP adoption performance.

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These results give substantial support to the general model developed in this study that predicts a contingency relationship between appropriation conditions (weak versus strong) and adaptation strategy (change the organization versus change the technology). For weak appropriation, the clear message is that firms need to change the company. Although these results are statistically significant and give clear direction of management decisions, the unexplained variance is still considerable, so caution is advised.

The results reaffirm the importance of leadership, especially the social learning theory of leadership. Demonstrate what you support, or walk the talk if you want people to follow major change. In short, the message is "live the vision." In the case of ERP adoption, this means hands-on usage by all general managers. Successful leaders also integrate quality and information technology adoption, use very focused goals and manage third-party relationships.

Results suggest other sources of variance not tested and a number of other, unanswered questions for future research. The specifics and blend of purchased technology tailored to the adopting firm and purchased as standard modules, are not revealed in these findings. We know only that when firms develop their own ERP systems, they lower their comparative adoption performance. It short, it slows a company down. Although this supports the general model, the details might be helpful for firms that are forced to do some maintenance of legacy systems due to growth and other reasons. Caution is advised in interpreting these findings since "package" or relative mixes between various supplier solutions in ERP suites remains a research issue.

The other, structured item findings suggest that business process reengineering figures importantly into the causal model of appropriation, but the details of this intervention were beyond the scope of this research. We know that firms pursue at least two types of overall deployment strategies, the "all or nothing, big bang approach" and the incremental approach. There are probably other strategies as well that need evaluation, including the sequence and scope of reengineering business processes. We found no pattern in the sequence (i.e., what to change first) for these firms, so this might be a topic for future research.

The finding that Internet usage figures into nearly half of these ERP adoptions and most of these cases are focused on customers is provocative for future research (goals focused on customers), and is consistent with published trends in the literature. For example, while data collection was in progress, IBM announced the intention to sell desktops computers on the Internet only as of January 1, 2000 (e.g., Auerbach, 1999). Suppliers of ERP like SAP are now also offering Internet versions of their systems and it is not clear how this will affect adoption performance and ultimate success with these complex systems. It is not clear how this will influence deployment of new ERP systems, but makes and interesting research question.

Adoption performance, of course, was used as a proxy for ultimate success with ERP in this study, and further validation of this variable is needed (e.g., Gattiker and Goodhue, 2000). It is quite possible that is variable can stand on its own as a unique construct, but more work will be required on this topic. The early returns here are quite promising and suggest that cost and strategic intent theory are fundamental in predicting outcomes of the purchase of major technology systems. It would also be interesting to see if the social learning model of leadership extends to middle management and lower ranks in the adopting firms, but with little evidence in this area, caution is advised in extending these findings lower in the ranks of companies. This is yet another topic for future research.

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Table 1: Correlation Matrix and Descriptive Statistics[a]

Variable	1	2	3	4	5	6	7	8
1. Adoption Performance	1.0							
2. Use BPR	.297**	1.0						
3. Acquisition Strategy (Buy %)	.279**	.260**	1.0					
4. Leadership	.306***	-.023	-.228**	1.0				
5. Use EDI	-.238**	.005	.050	-.009	1.0			
6. Start Date	-.268**	.086	-.042	-.047	-.061	1.0		
7. Sales	-.020	.132	.073	.097	.058	.041	1.0	
8. Industry (mfg v. serv)	-.087	.130	.312***	-.214**	-.030	.134	.060	1.0
mean	.000	.79	81.57%	4.88	.87	07/03/96	$8.14M	.61
(sd)	(.67)	(.37)	(22.35%)	(.76)	(.32)	()	($19.1M)	(.48)

[a] $p<0.1*$; $p<0.05**$; $p<0.01***$

Table 2: Regression Model for ERP Adoption Performance[b]

Variables	B	Standard Error	Beta	T	significance
Constant	31.036	13.870		2.238	.030
Use BPR	.488	.201	.267	2.427	.019
Acquisition Strategy (Buy %)	.001	.003	.337	2.889	.006
Leadership	.316	.097	.357	3.241	.002
Use EDI	-.557	.220	-.268	-2.535	.014
Start Date	.000	.000	-.257	-2.404	.020
Sales	.000	.000	-.081	-.760	.451
Industry (mfg v. serv)	-.167	.159	-.119	-1.047	.300

[b] Regression for Dependent Variable Adoption Performance: R=.654, R^2=.427, Adjusted R^2=.350, Standard Error of Estimate=.539. ANOVA results for the regression: $F(7,52)=5.54$, $p<.001$.

Figure 1: Appropriability Regime and Successful Adaptation Strategy

Adaptation Strategy

	Change Organization	*Change Technology*
Weak	*Improved Performance*	*Mixed Results*
Strong	*Mixed Results*	*Improved Performance*

Appropriability Regime