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Abstract:

Purpose: The delivered wisdom to date has enterprise system purchase and implementation as one of the most hazardous projects any organization can undertake. The aim was to reduce this risk by both theoretically and empirically finding those key predictors of a successful enterprise system deployment.

Design/methodology/approach: A representative sample of 60 firms drawn from the Fortune 1000 that had recently (1999-2000) adopted enterprise resource planning (ERP) systems was used to test a model of adoption performance with significant results.

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Findings: Leadership (social learning theory), business process re-engineering (change the company not the technology) and acquisition strategy (buy, do not make) were found to be significant predictors of adoption performance (final model $R2$ = 43 percent, F = 5.5, p<0.001, df = 7.52), controlling for industry (manufacturing versus service), project start date and scale (sales). Electronic data interchange (EDI) usage was found to be inversely and significantly related to adoption performance which supports the notion that prior company investments in earlier generations of technology for integration might inhibit adoption of later, more radical or complex alternatives. We validated these results with a focused follow-up study (2005) using mailed and interview protocols identical to the first questionnaire and 20 new cases of ERP deployment. We found near perfect agreement (p<0.001 binomial test) with our initial findings.

Originality/value: The "four factor" model we validate is a robust predictor of ERP adoption success and can be used by any organization to audit plans and progress for this undertaking.

Keywords: Corporate strategy, Leadership, Business process re-engineering, Information systems.

Paper type: Research paper

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Introduction

The challenge of implementing enterprise systems has been well documented in both the academic and the business press (McAfee, 2002; Deutsch, 1998). Enterprise integration, a technological intervention designed to achieve better organizational coordination, continues to be an elusive goal for many companies (Umble *et al.*, 2003). Large, new and expensive hardware-software systems have been touted as a solution to achieve integration (Davenport, 1998), but lasting benefits are often outweighed by escalating costs for these enterprise coordination systems (White *et al.*, 1997; Baker, 1998; Nelson and Ramstad, 1999, p. A1; Boudette, 1999)[1]. Furthermore, the future of enterprise resource planning (ERP) lies not in understanding integration from a narrow perspective, but rather in an interdisciplinary, theory-based, empirical approach to the subject, its causes and consequences (Ettlie and Joseph, 2005). The majority of firms have still not installed a fully useful enterprise system, and the smaller the firm, the more likely this is true (Duplaga and Astani, 2003).

The problem is not limited to enterprise integration. One earlier survey found that 42 percent of corporate information technology projects are terminated before completion (Wysocki, 1998). Many of these massive investments in computer technology are coincident with business process re-engineering (BPR) but these BPR projects fail to meet their objectives in 50 to 70 percent of the cases documented (Stewart, 1993; Roth and Marucheck, 1994; Rohleder and Silver, 1997). Throughout our discussion, the terms business process redesign and business process re- engineering are used interchangeably referring to "the critical analysis and radical redesign of existing business process to achieve breakthrough improvements in performance measures," (Teng *et al.*, 1994). Bad software alone cost US companies $85 billion in lost productivity in 1998 (Gross *et al.*, 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 adoption performance patterns of new information and process technology designed to intervene and promote coordination, e.g. ERP systems?

We found that leadership (social learning theory), BPR and acquisition strategy (make, do not buy) accounted for 43 percent of the variance in adoption performance for ERP Systems. Further, electronic data interchange (EDI) usage was significantly and inversely related to ERP adoption performance, showing how legacy commitments can slow progress with new technology.

Framing the adoption process

Recent innovation literature on *structure* (Gatignon *et al.*, 2002), and *dynamic capabilities* (Teece *et al.*, 1997) has found that innovations requiring acquisition of new competencies were significantly associated with both architectural and generational innovation. Further, the more radical the innovation, the more likely the acquisition of new competencies, apparently because radical innovation disrupts existing competencies and skills (Gatignon *et al.*, 2002, p. 1116).

Not only are ERP systems new and complex, but they are also typically purchased from suppliers. The ease of imitation issue includes the concept of appropriability regimes (Teece *et al.*, 1997, 526). The authors differentiate strong (e.g. patent protected products), weak (e.g. adopted technology) and intermediate appropriability regimes or conditions. Purchased ERP systems fall primarily in the weak conditions category.

We suggest that when process discontinuity (i.e. change in the technology of means or control of production or operations) is imminent, three essential constructs emerge as paramount:

1. leadership;
2. business process upheaval; and
3. re-evaluation of vertical integration of information technology, – the make-buy decision.

Although the first two are suggested directly by dynamic capabilities central to most organizations (Teece *et al.*, 1997), the last construct will require more development. This is partly because of the need to expand transactions cost economic theory and partly due to the trajectory of information technology in the present business context. The historical context of the innovating organization is quite important. In particular, the success of incremental change will retard radical innovation adoption (Zaltman *et al.*, 1973). The manifestation of this tendency in this context is the way in which successful adoption of EDI technology inhibits adoption progress with ERP technology.

These issues are developed more fully under the hypotheses section below.

Social learning theory, leadership and discontinuous change

In spite of the large and growing literature on organizational learning, little has been published on how to introduce learning in the workplace (Lipshitz *et al.*, 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. When new technology is 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; Bandura, 1977). This is the notion of "walking the talk", or exemplary action (Steyrer, 1998). Senior managers, 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). The leaders' demonstration of concern for member welfare can have a powerful impact on employee self-efficacy (Shea, 1999). Karahanna *et al.* (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), and lack of shared vision is often a problem in large system deployment like ERP projects (Amoako-Gyampah, 2004).

Therefore, the following hypothesis is offered for testing.

H1. Leadership through exemplary action promotes the successful adoption of discontinuous change, especially when adopting firm's general managers demonstrate a cohesive front of support vis-à-vis the new, complex 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. Successful senior managers have to live the vision when radical, complex change is afoot.

Adaptation strategy: business process re-engineering

What is the appropriate strategy for deployment of large, new technology systems, adopted from suppliers primarily outside the firm? There are a number of 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 BPR, or they have applied the wrong technology for change, and have not understood the value-added contribution of every business process (Guimaraes, 1997).

Tailoring ERP systems to meet the requirements of an organization is counterproductive for two important reasons. First, it is costly and the benefits from such an adapted technology are less likely to be forthcoming. Second, it tends to maintain the status quo within an organization, while changing purchased technology under weak appropriation conditions is counterproductive. Hypothesis two is offered for testing.

H2. Successful capture of benefits from purchased technology results from changing the organization (e.g. BPR) to leverage internal strengths for the future of the firm.

The typical information system adoption through outsourcing has been driven by cost reduction (DiRomualdo 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 BPR (Davenport, 1998).

Technology acquisition strategy and transaction cost economics

Appropriation issues, or conditions of benefit captured from investments, are discussed, for the most part, in transactions cost economics 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). 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. 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).

In general, firms integrate backward when their engineering effort is high in a core technology (Masten *et al.*, 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 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). The dramatic demands of implementing these ERP systems may distract a company's focus from its core products and services, and efforts to deploy complex, new adopted technology systems without such a company focus 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 such as the ERP suppliers. For example, Oracle Corporation recently installed their own ERP system (Hamm *et al.*, 2000).

The second part of this argument is that purchased information technology needs to be coupled with successful BPR (*H2*). Under 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. BPR represents major organization change, but is the necessary step for success.

> *H3.* Successful adoption 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, the more successful they will be. This allows the firm to continue to focus organizational change using BPR and to concentrate R&D resources on new products and services.

Methodology

A mailed survey using a two-page questionnaire of large US companies in the Fortune 1,000 resulted in a representative sample of 60 companies that had recently adopted ERP systems in 1998- 1999. 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. We calculate our effective response rate was between 13 and 16 percent. Mabert *et al.* (2000) reported a 9.6 percent response rate for an ERP survey done about the same time, but just among manufacturing firms on the American Production and Inventory Control Society (APICS) membership list. Mabert *et al.* (2000) reported that 44 percent of these firms were actually implementing ERP at that time. If this is a proxy for the penetration rate of ERP in 1998-1999, then only about 44 percent of the manufacturing firms in the Fortune 1000 were actually eligible for the survey reported in this study. This seems reasonable because AMR estimated the penetration rate of ERP in 2000 to be 57 percent and 65 percent in 2001, which is an increase of 8 percentage points in one year (www.oracle.com/corporate/press/index.html?1236512.html). This would give a penetration rate of about 45 percent (0.57−0.12) during the 1998-1999 time period, the same as Mabert *et al.* (2000) reported. Since the Fortune 1000 is 40 percent manufacturing firms, that is only 176 (0.44×400) eligible. The actual response split in the current survey was 60 percent manufacturing, suggesting that the penetration rate in service was 20 percent less than manufacturing, suggesting that only about 35.2 percent (0.44×0.2=0.88; 0.44−0.088=0.352) of service firms in 1999 were eligible for the survey, or about 211 service firms in the Fortune 1000 (600×0.352). The grand total of eligible firms would be 387 companies (176 manufacturing+352 service), which would result in an effective response rate for this survey of approximately 15.5 percent (60/387).

Our usable response rate was 6 percent (60 of 1,000 returned complete with 10 responses thrown out) compiled in 2000. Comparisons were made between the Hoovers archive compiled on the Fortune 1000 and the sample as baseline. 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 percent manufacturing and 60 percent non- manufacturing, whereas type of responding firm distribution was just the opposite: 60 percent manufacturing and 40 percent 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 (Deutsch, 1998). For example, at the time of the survey, SAP currently held 32 percent of the market share of ERP systems (Boudette, 1999), and in this sample of 60 companies, SAP had 30 percent of the adoptions. Further, R&D spending as a percentage of sales as reported and as shown in the computer files for the Fortune 1000 were very significantly correlated (r=0.87, p<0.001). We concluded that this was, indeed, a representative sample of on-going and completed ERP installations in large US companies.

The survey instrument was developed by doing six case histories of ERP deployment with an industry associates group of the University of Michigan Computer and Information Systems Department and we are grateful for their assistance and that of Professor Dennis Severance for their help.

Adoption performance

The dependent variable[2] of the study was adoption performance or the degree of progress towards full-scale, successful implementation of the ERP system under investigation (Ettlie *et al.*, 2003). 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 and that timing and budget performance are related. Many ERP systems are never implemented (Yusuf *et al.*, 2004). This rationale is a variant on the first-mover strategy. ERP projects can take six months to several years to complete, so there is ample variance to study in the field (Okrent and Vokurka, 2004). Mabert *et al.* (2003) as so many other researchers have done, use on-time and on/under budget performance to measure implementation success.

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 percent); and "Relative to other companies in your industry, are you ahead (scene 3), even (scene 2) or behind (scene 1) on project outcomes?" Factor analysis with principal components of these two items yielded a factor score of 0.85, communality=0.73, and an eigenvalue=1.45, accounting for 72.6 percentage of variance in comparative, adoption performance. The intercorrelation of these two items was $r=0.45$ ($p=0.014$).

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 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 percent), 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 percent), 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 $b=0.418$, $p=0.061$ ($n=14$). The Pearson $r=0.439$, $p=0.058$ ($n=14$).

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 (Nunnally and Bernstein, 1994). 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.

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 $r=0.589$ ($p=0.021$). Because the larger firms were more likely

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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 $\beta=0.582$, $t=2.271$, $p=0.044$. Firm sales did not contribute significantly to the regression with $\beta=-0.130$, $t=-0.509$, $p=0.620$. This regression analysis indicates that the 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 US 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);
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
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 2000], cycle time reduction, and global data integration), which scores sd≤15 percent as 1 and sd>15 percent as zero.

The new leadership scale was created by summing these five items, since the highest value indicated "more" leadership in each item. The Cronbach *α* for this five-item scale was 0.64 and the standardized item *α* was 0.66.

Adaptation strategy: business process re-engineering

Our model calls for significant organizational innovation and change, or major process technology adoption. In this case, for the adoption of ERP, we predicted that BPR needed to be used. There was one, two-part item on the questionnaire related to BPR. The question reads as follows: "If BPR was done, which process was re-engineered." 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 no. We also investigated the order in which BPR 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 (percent), buy (percent), or buy tailored (percent) systems? (what proportions?)" Respondents would then list, 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 percent 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 percent of the sample, coded "1") and non-manufacturing (e.g. service, or 40 percent of the sample, coded "0") using Standard Industrial Classification (SIC) information on each firm. It should be recalled that the Fortune 1000 composition is just the reverse of this sample proportion: 60 percent service and 40 percent non-service. ERP appears to be more popular among manufacturing firms. EDI usage has been reported as critical in separating efficient users of information technology (Deloitte and 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 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. In this way, we continued to explore the contextual notion of the "tyranny of incrementalism". Project start date was included as the final control variable to establish a base line for comparison in the dependent variable.

Validation survey

In spite of growing problems with low response rates in survey studies of information technology, we did boldly go forward with a follow-up validation study in 2005 – exactly five years after the final completion of our first survey results. Data was collected using a two-page questionnaire mailed to Chief Technology Officers and other upper-level management personnel involved in technology roles (i.e. Chief Scientific Officer). The list of contacts was compiled from the Hoovers Online Database for manufacturing firms in SIC 34-39. A total of 314 questionnaires were mailed during the second week of January 2005. Of these 314, six were returned as undelivered or ineligible for the survey (e.g. no ERP system deployment underway). A total of four usable questionnaires were returned from this survey, so call-backs were initiated with a random sample of 35 non-respondents. This resulted in a determination of an additional six cases that were ineligible. So we assumed that the actual number of eligible cases in the original survey list was (6/35=17 percent or 54 cases ineligible) so the effective survey response rate of the mailing was 1.57 percent (314- 54=260-6=254 actually eligible; leaving an effective response rate of 4/254=1.57 percent).

Given the fact that we had very limited survey budgeted resources, and the difficulty in getting responses by this method for ERP research, we asked graduate students in two of our executive MBA classes to fill out the questionnaire if their company had been involved in an ERP deployment. This generated an additional nine completed questionnaires, and this was added to seven other questionnaires returned when we asked industry associates we know to be involved in ERP installations to help us with this validation effort. The quid-proquo in each case was the immediate summary of our original findings from 2000. A total of 20 new ERP deployment cases were generated using these three methods in early 2005 (four from the survey, nine from executive MBA students and seven from industry associates), which we felt would be more than adequate for validation purposes of the 60 responses of our original survey, and six pilot case studies we did to start the original project.

The validation consisted of making predictions of outcomes based on the "four-factor" model (leadership, BPR, acquisition strategy and EDI usage). We coded the data in a way similar to the methods used for the original data (Table III) and conducted an inter-rater reliability test for the validation.

Two independent judges, not involved with the first data collection or study, compared predicted self-reports of outcomes on the dependent variable measures (percent of budget expended and comparisons with competitors) coded as: ahead, even or behind on ERP deployment. The judges scored a case as "1" if it validated the model, and "0", if it was at odds with model predictions. The results showed near perfect agreement between the two independent judges, r=0.840 (p=0.24, n=20). The first judges scores were used since they were in perfect agreement with the first author's independent ratings (the third "judge"), in this case. This resulted in 17 of the 20 cases being valid predictions of the four-factor model, which is statistically significant (p<0.001, binomial test).

Results

The correlation matrix, with descriptive statistics, and regression analysis summary appear in Tables I and II, respectively, for the original survey compiled in 2000. The final regression model is detailed in Table I. Regression results are ordinary least squares (OLS) using mean substitute for missing data in this analysis. Correlations with and without mean substitution were compared and no significant differences were found.

The overall regression equation is significant (F=5.54, p<0.001, with 7,52 degrees of freedom), and accounts for 43 percent of the variance in the dependent variable (35 percent of the variance adjusted for degrees of freedom). Both standardized regression coefficients (β) and unstandardized coefficients (b) and standard errors are reported in Table II.

Results that are reported in the summary regression equation in Table I 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 $\beta=0.357$ ($p=0.002$). BPR ($\beta=0.267$, $p=0.019$) 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 percent) is significantly and directly related to adoption performance ($\beta=0.337$, $p=0.006$). Buying tailored systems and companies writing their own software do not enter this model. Although the "make" percentage does not enter this equation, it was inversely related to the dependent variable ($r=-0.355$, $p=0.075$, two-tailed test, $n=26$), consistent with these results. The interaction term of BPR × percent buy was checked in a regression with the other predictors and control variables and was found to be non- significant ($\beta=-0.389$, $t=-1.174$, $p=0.246$).

Two of the control variables were not statistically significant (sales and industry). On the other hand, both EDI usage ($\beta=-0.268$, $p=0.014$), and start date ($\beta=-0.257$, $p=0.02$) 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 variable does not, in any way, diminish the other main effects in this model which are very robust.

[Table I]

[Table II]

Validation of results with data from 2005

In Table III, we present the results of our follow-up investigation (2005 data) to validate our results using the same two-page questionnaire which also was used as an interview guide in at least one case. So, nearly five years to the day, we have 20 new cases to use for validation of our original results. This creative replication of the "four factor" model (Leadership, adaptation strategy, acquisition strategy and EDI) was strongly supported by follow-up cases of ERP adoption in a wide variety of settings, including two universities, industrial products, machine tools, and others. In 17 of the 20 cases, there was near perfect prediction of the outcomes (to date) using the four factor model ($p<0.001$, binomial test). The details of this validation are also quite interesting as summarized in Table III. Not only was the four factor model quite successful in predicting actual outcomes, the *leadership* variable was the most difficult one for cases to satisfy. Not a single firm in the validation sample scored a perfect 7 on leadership, and in particular, the key factor, the social learning dimension – ERP hands-on by general managers, was satisfied in only 7 of the 20 cases. As the management literature has predicted all along, effective leadership is a rare commodity in most companies.

Related to this outcome was that focused goals was another area where firms do seem to struggle, with only 3 of the 20 companies achieving a standard deviation of scores of less than or equal to 15 percent. Again, goal structure of these projects is a general management function.

Discussion and Conclusions

In the context of a very expensive, complex purchased technology (ERP), we found that leadership, BPR and acquisition strategy (do not make, but buy) were significant predictors of adoption performance. These results persist when controlling for industry and scale of operations (i.e. sales). For this context, successful adoption of EDI technology inhibits adoption progress with ERP technology. This four factor model persists over a five year elapsed time (2000 versus 2005) since the original data collection which suggests that theory-based research in this field is well rewarded by robust empirical findings.

[Title III]

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, and yet, this may be the most difficult part of this process to achieve, based on our most recent validation of earlier findings.

Future research

Results suggest other sources of variance not tested and a number of other, unanswered questions for future research. For example, 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. In 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 or 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 BPR figures importantly in the causal model of ERP adoption, 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 re- engineering business processes.

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) and linking with operational performance outcomes would be useful. It is quite possible that a 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. However, with little evidence in this area, caution is advised in extending these findings in the lower ranks of these companies. This is yet another topic for future research.

When the results from this study are considered with previous research (Teece *et al.*, 1997; Ettlie, 1997; Davenport, 1998), they suggest a contingency relationship between appropriation conditions (weak versus strong) and adaptation strategy (change the organization versus change the technology). The present study explores weak appropriate conditions because the firms that purchase new technology systems enter this world (of weak appropriation conditions) and they are challenged to secure and protect any gains this technology might provide over competitors who often adopt the same new systems. For weak appropriation situations like ERP adoption, the clear message is that firms need to change the company. The alternative, strong appropriation conditions for new products (desired), suggests the opposite approach to adoption, namely not outsourcing software.

A third category, intermediate appropriation conditions remains (Teece *et al.*, 1997). 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. What is the link between enterprise systems and R&D or design? Although current results are statistically significant and give clear direction of management decisions, the unexplained variance is still considerable; caution is advised. Intermediate appropriation conditions (e.g. purchase of tailored software to support collaborative engineering of new products) remain virtually unexplored in this context, and would be a fruitful theoretical avenue to pursue in this context.

Notes

1. Enterprise resource planning systems are defined by leading supplier SAP as follows:

"Enterprise resource planning (ERP) is an industry term for the broad set of activities supported by multi-module application software that helps a manufacturer or other business manage the important parts of its business, including product planning, parts purchasing, maintaining inventories, interacting with suppliers, providing customer service, and tracking orders. ERP can also include application modules for the finance and human resources aspects of a business. Typically, an ERP system uses or is integrated with a relational database system. The deployment of an ERP system can involve considerable business process analysis, employee retraining, and new work procedures".

2. Adoption performance can be derived. Our starting point is the original idea that there is continuous, but often incremental escalation in firm's performance standards (March and Simon, 1958). Time dependency and temporal patterns is representative of much of the innovation literature (Rogers, 1962; Angle and Van de Ven, 1989, p. 693; Gopalakrishnan and Damanpour, 1997, Ettlie, 2000). 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 et al., 1992), and for advanced manufacturing technology (Zairi, 1992). This appears to be quite germane to this context where many well known companies either never finish their ERP adoption (implementation) or take much longer to make progress than expected. We define the dependent variable in this study, adoption performance, 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. At a recent conference with multiple presenters (Ettlie et al. 2003), the concept of "finishing" an ERP deployment was discussed at length and the idea that many of these projects simply are never over emerged as a key challenge in this field.

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Further reading

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Table I. Correlation matrix and descriptive statistics

Variable	1	2	3	4	5	6	7	8
1 Adoption performance	1.0							
2 Use BPR	0.297**	1.0						
3 Acquisition strategy (buy percent)	0.279**	0.260**	1.0					
4 Leadership	0.306***	20.023	20.228**	1.0				
5 Use EDI	20.238**	0.005	0.050	20.009	1.0			
6 Start date	20.268**	0.086	20.042	20.047	20.061	1.0		
7 Sales	20.020	0.132	0.073	0.097	0.058	0.041	1.0	
8 Industry (mfg versus serv)	20.087	0.130	0.312***	20.214**	20.030	0.134	0.060	1.0
Mean (SD)	0.000(0.67)	0.79(0.37)	81.57%(22.35%)	4.88 (0.76)	0.87(0.32)	07/03/96	$8.14M($19.1M)	0.61(0.48)

Note: *p < 0:1 **p < 0:05 ***p < 0:01

Table II. Regression model for ERP adoption performance

Variables	b	Standard error	β	t	Significance
Constant	31.036	13.870		2.238	0.030
Use BPR	0.488	0.201	0.267	2.427	0.019
Acquisition strategy (buy percent)	0.001	0.003	0.337	2.889	0.006
Leadership	0.316	0.097	0.357	3.241	0.002
Use EDI	-0.557	0.220	-0.268	-2.535	0.014
Start date	0.000	0.000	-0.257	-2.404	0.020
Sales	0.000	0.000	-0.081	-0.760	0.451
Industry (mfg versus serv)	-0.167	0.159	-0.119	-1.047	0.300

Note: Regression for dependent variable adoption performance: R = 0:654; R^2 = 0:427; adjusted R^2 = 0:350 and standard error of estimate=0.539. ANOVA results for the regression: F(7; 52) = 5:54 and p < 0.001.

Table III. Validation results

Case	Industry	(Beta Weights) Leadership (0.357)[a]						BPR	Acquisition	EDI usage		Actual		Validation
		Hands on	Quality	3rd Parties	Strategy	Goals	TOTAL	(0.267)[a]	Strat. (0.337)[a]	(-0.268)[a]	Y = b1X1 + b2X2 + b3X3 + b4X4	Proportion Done (%)	Project Outcome	Outcome
1		0	0	1	3	1	5	0	1	1	1.854	75	A	Ok
2	Food	0	0	1	2	0	3	1	1	1	1.407	10	A	No
3		0	0	1	1	0	2	1	1	1	1.050	50	E	Ok
4	Diversified Products	0	1	1	3	0	5	1	0	1	1.784	25	E	Ok
5	Telecom	1	0	1	1	0	3	1	1	-1	1.943	75	E	Ok
6		0	1	1	1	0	3	1	1	-1	1.943	75	E	Ok
7	Manufacturing Home	1	1	1	3	0	6	1	0	-1	2.677	75	A	Ok
8	Chemical	0	1	1	3	1	6	1	0	1	2.141	100	A	Ok
9		1	1	1	2	0	5	1	1	1	2.121	50	A	Ok
10	Machine Tool	0	1	1	1	0	3	1	1	1	1.407	100	E	Ok
11	Printing Equipment	0	0	0	1	0	1	0	1	-1	0.962	100	E	Ok
12	Container	1	1	1	3	0	6	1	1	1	2.478	100	E	No
13	Power Gen. (Pub. Uti	1	1	1	2	0	5	1	1	1	2.121	40	A	Ok
14	Office Equipment	0	1	1	3	1	6	0	1	-1	2.747	10	A	Ok
15	Industrial Systems	1	1	1	1	0	4	0	1	1	1.497	10	E	Ok
16	Optical gauges	1		0		0	1	0		-1	0.625	0	A	No
17	Computers	0	0		2	0	2	1	1	1	1.050	50	B	Ok
18	Electronics		1	1	2	0	4	0	0	-1	1.696	100	E	Ok
19		0	1	1		0	2	1	1	1	1.050	25	B	Ok
20	High Tech manufactu	0	0	1	2	0	3	0	1	-1	1.676	100	E	Ok
21														
22											Mean = 1.711			
23														
24														**17/20 valid**
25														
26														**P = 0.0013**
27														
28														
29														
30														

[1] max = 3.371 ; min = 0.089
[a] 2000 Data (Beta)

Leadership					BPR	Acq. Strategy	EDI usage	Project Outcome
Hands on	Quality	3rd Parties	Strategy	Goals				
Q 23	Q 21	Q 11	Q 18	Q 3	Q 2	Q 19	Q 8	Q 24
1 = yes	1 = yes	1 = yes	1 = unfocused	1 = σ ≤ 15%	1 = yes	1 = buy ≥ 80%	1 = yes	A = ahead
0 = no	0 = no	0 = no	2 = between-focused	0 = σ > 15%	0 = no	0 = buy < 80%	-1 = no	E = even
			3 = very focused					B = behind

Table III.
Validation results