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Enterprise Resource Planning (ERP) for the Next Millenium: Development of an Integrative Framework and Implications for Research

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Abstract

The development of Enterprise Resource Planning (ERP) software packages in the 1990's has turned the enterprise software market into one of the industry's hottest and most volatile segments on the threshold of a new century and a new millennium. The high failure rate of ERP implementations, and the mixed results of ERP systems, necessitate investigations that enhance our understanding of the issues involved in implementing these complex systems and provide help with devising implementation strategies that lead to success. To develop a deeper understanding of ERP systems, we propose an integrative framework and taxonomy derived from the socio-technical view of organizations and other extant theories that illustrates the multifaceted nature of ERP implementations.

Introduction

Enterprise Resource Planning (ERP) software, which attempts to integrate all departments and functions across a company into a single computer system, is one of the fastest growing segments in the software market and one of the most important developments in information technology in the last decade. A recent survey of 800 U.S. companies showed that ERP was commanding 43% of the companies' application budgets with ERP systems installed in almost half of these companies (AMR Research, 1999a). The global market for ERP software is expected to grow to $66 billion by 2003 (AMR Research, 1999b). Market penetration of ERP varies considerably from industry to industry: 76% of manufacturers already have an ERP system or are installing one versus 35% of insurers and health care companies and 24% of federal government agencies (Stedman, 1999). With over 60% of the U.S. Fortune 100 penetrated, major ERP vendors are increasingly targeting small- and medium-sized enterprises (SMEs) to generate new sales. Vendors and users are also moving beyond core applications to extend ERP systems to support Web-based applications, e-commerce, customer-relationship management, and business planning (Stein, 1999b; Stedman, 1999).

The growing demand for ERP applications has several reasons: competitive pressures to become a low cost producer, expectations of revenue growth, achievement of competitive advantage in the market, ability to compete globally, replacement of out–of-date technology, Y2K-related replacements, the desire to re-engineer the business to respond to market challenges, and the phased introduction of the Eurocurrency (Loizos, 1998). Promising the seamless integration of all the information flowing through a company (Davenport, 1998), benefits of a properly selected and implemented ERP system can be significant: inventory holding cost reductions by 25 to 30%, raw material cost reductions by 15% on average, and reductions in lead-time for customers, production time and production costs (Gunn, 1998; Main, 1990; Schlack, 1992).

Despite the fact that "the business world's embrace of enterprise systems may in fact be the most important development in the corporate use of information technology in the 1990's" (Davenport, 1998b), broad-based empirical research in this area is very sparse. Current work, much of which is research-in-progress, on critical issues affecting ERP implementations (e.g., Brown and Vessey, 1999; Sumner, 1999; Stratman and Roth, 1999), costs and benefits of ERP (Gattiker and Goodhue, 2000), and the significance of training in ERP implementations (Mahapatra and Lai, 1998) has been largely anecdotal in nature or based on case studies of organizations. Most of our knowledge about ERP systems is derived from the practitioner and trade literature which is replete with prescriptive approaches to ERP implementations. Adding to this is the recent suggestion that many ERP installations achieve only partial implementation and nearly one in five are scrapped as total failures (Trunick, 1999). ERP implementations are complex and fraught with many problems. It is imperative that academic researchers begin ambitious streams of research to explore the factors that are critical to the success of ERP projects. Contributions to the literature are needed to guide companies who are seemingly caught up in a tangle of unanswered questions about ERP. The gnawing questions are: What are the key factors, uncertainties, and interactions that are likely to impact ERP implementations and subsequently the organization's performance? As a package implementation, what distinguishes an ERP implementation from the implementation of custom software (Gable, 1998)? What is the organizational impact of ERP as convergence of enterprise applications accelerates? What benefits are actually realized by companies and how should they be measured? Do the long-term benefits clearly outweigh the short- to mid-term costs that the implementation decision requires? Furthermore, a theory base must be developed and validated for ERP that explains and predicts the effects of adopting ERP systems on developing and managing

business information processing capabilities (Stratman and Roth, 1999).

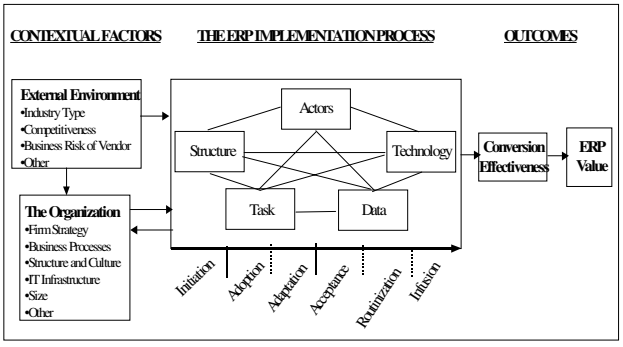
Drawing from the large body of literature on information systems (IS) implementation and failures, business process reengineering (BPR), and organizational change management, the objective of this article is to develop a more systematic account of ERP implementations that is useful for guiding implementation management and advancing ERP research. Specifically, we propose a unique approach that involves the application of the socio-technical model of systems development to ERP implementations. It provides us with a basis for identifying and classifying Critical Success Factors (CSFs) according to the model's components and their interdependencies, developing causal relationships, and explaining ERP's impact and value-added on a number of organizational dimensions. We also use it as a basis for developing a CSF/Implementation Stage model that accounts for the temporal dimension of the implementation process. We conclude by identifying research opportunities and present specific research questions raised by this conceptual framework.

A Sociotechnical Model of ERP Implementations

In developing a model of ERP implementation, we integrate: (1) the IT implementation and diffusions research literatures (Kwon and Zmud, 1987; Cooper and Zmud, 1990); (2) the IT failure classification framework (Lyytinen and Hirschheim, 1987); (3) the sociotechnical view of system development (Lyytinen, Mathiassen, and Ropponen, 1998), and (4) the IT interaction model (Silver, Markus, and Beath 1995). The conceptual model shown in Figure 1 has three major components: the ERP implementation process, contextual factors, and outcomes.

The ERP implementation process has two dimensions: domains and stages. The core of the implementation process consists of five interacting domains each of which represents a choice for the organization and whose characteristics and interactions are believed to influence the value of the system for the organization: *actors* (users, managers, and designers), *technology* (development tools and technical platform), *task* (expected outcomes in terms of deliverables), *structure* (project organization and other prevailing institutional arrangements) (Lyytinen et al. 1998), and *data*. From a temporal perspective, the implementation process can be viewed as consisting of six phases: initiation, adoption, adaptation, acceptance, routinization, and infusion (Cooper and Zmud, 1990). Interacting with these design choices are contingencies from the organization's internal environment such as the firm's strategy, business processes, structure and culture, and IT infrastructure (Silver et al, 1995), and firm size. Also important are factors in the organization's external environment such as the type of industry in which it operates and the company's competition. The value of an ERP system is at least partially determined by the probability of effectively converting investments in the system into useful output (Lucas, 1999).

Figure 1. ERP Implementations: A Conceptual Model



Critical Success Factors in ERP Implementations

What are critical attributes of successful ERP implementations? A number of factors that affect the implementation process and the probability of conversion success have been identified in the IT implementation, IT failures, and business process reengineering literatures (Kwon and Zmud, 1987; Applegate, McFarlan, and McKenney, 1999; Lyytinen, et al. 1998). Among the more important factors are top management support and involvement (Jarvenpaa and Ives, 1991), the need for a project champion (Beath, 1991), user training (Nelson and Cheney, 1987), technological competence, process delineation, project planning, change management, and project management (Grover, Jeong, Kettinger, and Teng, 1995). In the context of ERP implementation, additional issues include the need to reengineer business processes prior to implementation, the need to communicate effectively and set appropriate expectations, the use of a balanced IS and business team (Bancroft, Seip, and Sprengel, 1998), and the avoidance of customization (Sumner, 1999). To date there has been no systematic attempt to identify, organize, and synthesize factors associated with ERP successes and failures nor have measures been proposed and tested. We have classified the factors identified in the extant literature according to the domains shown in Figure 1 and similar to Lyytinen et al (1998) to develop a taxonomy of CSFs that illustrates the need for embracing a systems approach for researching ERP implementations and devising appropriate implementation strategies.

Actors---Actors are the stakeholders who can set forward claims or benefit from software development (Lyytinen et al. 1998). In the context of an ERP project, actors would include the customer (organization), software vendors (developers), and users. Critical success factors related to this domain include: top management support, project

champion, user training and education, management of expectations, and vendor/customer relationships.

Technology--Use of Vendors' Development and Customization Tools: There are indications that rapid implementation technologies and programs can significantly reduce the cost and time of deploying ERP systems. An additional goal of implementation tools is the transfer of knowledge with respect to using the software, understanding the business processes within the organization, and recognizing industry best practices

Structure--Neglect of the structural dimension, i.e., the project organization is likely to generate considerable difficulties in implementing the system within time and budget constraints and getting the system accepted (Lyytinen et al. 1998). Important aspects of the structural dimension that need to be managed well include careful selection of the technology, project management, the steering committee, and the use of consultants.

Task--In the context of system development, the task has been defined in terms of project deliverables and process features. The greater or more complex the project the greater the exposure to risk (Lyytinen, Mathiassen, and Ropponen, 1998). Keeping the system simple, i.e., *minimal customization*, is one approach that has been associated with successful ERP implementations.

Data--A fundamental requirement for the effectiveness of ERP systems is the availability and timeliness of accurate data. Data problems can cause serious implementation delays, and as such, the management of data entering the ERP system represents a critical issue throughout the implementation process (Kapp, 1998). Within the company, the challenge lies in finding the proper data to load into the system and converting all those disparate data structures into a single, consistent format.

Organization-Technology Interaction--One of the problems associated with implementing packaged software is the incompatibility of features with the organization's information needs and business processes (Janson and Subramanian, 1996; Lucas, Walton, and Ginzberg, 1988). Organizations deploy ERP systems to standardize business practices and in many instances, ERP systems create the need for a new organizational structure that reflects the ongoing need for ERP related activity. In order to maximize the benefits of ERP investments, the supplementary redesign of business processes promises the highest ROI, but also increases the level of complexity, risks and costs (Kirchmer, 1998). A number of methodologies, techniques, and tools have been developed for conducting BPR.

Organization -Task Interaction--Dedicated Resources: An organization's failure to commit the required financial, human and other resources has been found to be a problem in reengineering implementations (Grover et al., 1995).

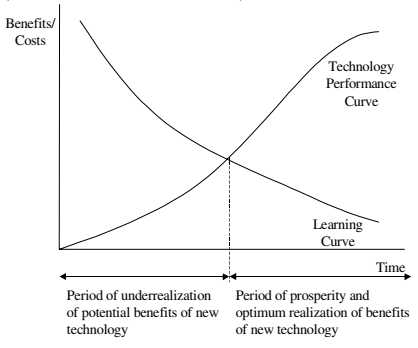
Actor-Structure Interaction -- Project Team Competence: Another decisive element of ERP implementation success or failure is related to the knowledge, skills, abilities, and experience of the project manager as well as selection of the right team members, which should not only be technologically competent but understand the company and its business requirements (Trepper, 1999; Mendel, 1999; Kapp, 1998).

Organization -Actor-Technology Interactions--Change Management: Managing change is the number one concern of many involved in ERP implementations (Maxwell, 1999). ERP systems introduce large-scale change that can cause resistance, confusion, redundancies, and errors. It is estimated that half of ERP implementations fail to achieve expected benefits because companies "significantly underestimate the efforts involved in change management" (Appleton, 1997).

Integrating the Temporal Dimension

The goal of any implementation is to bring the new system on line smoothly, to minimize any period of underrealization of the benefits of the new technology, and to maximize the magnitude of the benefits and the time period over which they are realized (Noori, 1990). As illustrated in Figure 2, proper management will accelerate the pace of the learning curve, which for ERP is at least 6 months, and accelerate the realization of technology benefits, allowing the two curves to intersect earlier and diverge faster after intersection.

Figure 2. The Goal of Implementation Management (based on Noori, 1990)



ERP Value

As ERP projects move toward conclusion in many corporations, the issue most under scrutiny at present is the need to establish the business benefits from such major investments. Unfortunately, many organizations fail to see immediate benefits from moving to ERP, are unable to realize positive returns on their investments or even experience adverse effects like missed sales and profit targets (Michael, 1998). As we propose in this article, problem-ridden implementations appear to be one reason. Benefits are unlikely to accrue if the software package selected is inappropriate for the company (Olinger, 1998). Many companies have difficulties with determining what to measure given all the statistical features that ERP software has to offer (Appleton, 1997).

In addition, companies need to realize that the highest benefits of ERP may only be achievable in the infusion stage when ERP installations are mature and "the IT application is used within the organization to its fullest potential" (Cooper and Zmud, 1990, p. 125). It therefore appears necessary to distinguish between both short-term and long-term benefits of performance to account for the nature of the diffusion process. Finally, benefits may vary among organizations using the same applications due to differences in organizational characteristics (e.g., Ragowsky, Ahituv, and Neumann, 1996).

Implications for Research

In developing our conceptual framework for studying ERP implementations, several distinguishing characteristics of ERP implementations emerged. The systems are profoundly complex pieces of software requiring large investments of money, time, and expertise (Davenport, 1998). In addition, ERP implementations are implementations of dedicated packages which differ from the implementation of a custom system in three ways: (1) the user may have to make changes to business processes and procedures, or (2), the user may need to introduce customizations, and (3) the user becomes dependent on the vendor for assistance and updates (Lucas, Walton, and Ginzberg, 1988). Finally, some degree of business process engineering is usually involved in ERP implementations. Research has shown that reengineering projects "are more complex, involve more factors, and are more dynamic and unpredictable than conventional MIS projects" (Grover et al., 1995). Our framework suggests some preliminary insights and presents many areas in which research is needed.

Critical Success Factors

One implication is for researchers to identify and empirically validate critical success factors associated with ERP implementations similar to studies investigating CSFs for information center managers (Magal, Carr, and Watson, 1988) and strategic alliances in the IT industry (Rai, Borah, and Ramprasad, 1996). Future research may also involve categorizing CSFs into four levels of criticality and three sets of dichotomous attributes (e.g., direct/indirect) according to the taxonomy proposed by Williams and Ramaprasad (1996). Some specific research questions that emerge include:

- What characteristics define a successful ERP implementation? What factors contribute to the success or failure of ERP implementation? How do CSFs vary in importance among themselves?
- Are their differences in perception of the importance of CSFs among the stakeholders (top management, project management, IT management, users)?
- Which domains and interactions between domains shown in Figure 1 account for the most important CSFs?
- Which CSFs make the difference between incremental results and breakthrough results? What are the relative influences of CSFs on conversion success and ERP value?
- Which stage (or stages) should receive more emphasis in order to achieve higher implementation success?
- What are differences in the ERP Implementations Stage/Critical Success Factor Profiles (Table 2) between successful and unsuccessful implementations?
- Do CSFs vary across industry sectors?
- Do CSFs vary between custom development projects and ERP projects?

Implementation Phases

Research is also needed that provides a better understanding of activities within individual project stages and their relationship to success. Some of the questions include:

- Which factors are used in the selection of an ERP package? Which considerations are most important when selecting an ERP package? Is the effort expanded on selection related to implementation success?
- Are well-formulated vendor selection policies positively associated with implementation success?
- Is there a correlation between conversion strategy and ERP success?

Implementation Domains

Future research can also target implementation issues related to specific domains or interactions between the domains shown in Figure 1.

Structure

- What is the governance structure of successful ERP projects, i.e., who makes what decisions?
- Does the use of consultants contribute to more successful implementations? Under which circumstances?

Actors

- **Users**: What effect does training have on implementation and utilization of the ERP software? How much training is enough? What type of training is most effective?
- **Executive management**: What is the nature of top management participation and involvement in ERP projects? How is it related to ERP implementation success?
- **Vendor:** What are important attributes of good vendor support?

Technology

- What is the effect of renting ERP on the management of such systems?

Task

- How many modules should be implemented? Which functionalities? Is there a relation between the number of modules/functionalities implemented and ERP implementation success?
- How does the best-in-breed strategy affect implementation time and implementation success?

Organization-Technology

- What is the nature and extent of changes to ERP systems to fit unique requirements?
- What is the mix of technologies from different vendors to meet organizational requirements? Is there a relationship between use of multiple vendors and strategic impact?

Organization-Vendor

- Given the dependence of the organization on the vendor for maintenance and upgrades, what is the role of the ERP software vendor within the organization? How are vendor-customer relationships structured in successful ERP projects over time?
- What are the best processes for managing vendor relationships? What characterizes successful vendor-customer relationships?
- What is the nature of the relationship between vendor and customers when a best-in-breed strategy is pursued?
- Which contingency factors affect the choice of best-in breed versus single-vendor strategy? What is the impact of either approach on implementation success?

Contextual Factors

As "the difficulty in successfully implementing an IS lies in the complexities of the organization's internal and external environments" (Kwon and Zmud, 1987, p. 244), much research is needed on the influence of variables surrounding the ERP implementation process.

Environmental Characteristics

- How do industry-specific idiosyncrasies affect the adoption and implementation of ERP systems?
- How do characteristics of supply chain partners impact adoption/implementation of ERP systems?

Organizational Characteristics

- Implementations so far have been primarily in large organizations. Given more limited resources, what is the impact of organizational size on the choice of vendor, implementation, and project management practices? Which approach of engaging external expertise is better for small or medium-sized businesses (vendor-only or consultant vendors)? Do profiles of successful implementations/ CSFs differ between large and small companies? What problems do small companies experience in ERP implementations that are different from large companies? Are benefits contingent upon the size of the company? Is the size of the company related to adopting a single-vendor versus a best-in-breed strategy? Is the size of the company related to less modification of ERP code?
- Is there a correlation between the learning orientation of the organization and implementation success?
- Is there a relationship between success on previous IT projects and ERP implementation success?
- According to Applegate, McFarlan, and McKenney (1999), the implementation risk of an IT project is high if a company is perceived as backward in the use of IT. Is there a correlation between the company's general attitude toward innovation (innovator, early adopter, early majority, late majority, and laggards) and implementation success?
- In a tightly, centrally coupled organization, it makes sense to have a tightly coupled, shared database, and uniform presentation of the applications. Running ERP from one location makes sense for companies that operate as centralized organizations (Kay, 1998). What is the impact of organizational structure (centralized/decentralized) on ERP implementation?
- Is an alignment of IT strategy with business strategy related to ERP success?
- Is the type of an investment in the ERP system (i.e., infrastructure, strategic, etc.) for the company related to ERP value?
- How do global rollouts differ from domestic rollouts? Given the increased complexity, are global rollouts more failure-prone than domestic ERP projects? Do global rollouts achieve greater benefits from standardization than domestic rollouts?
- For which companies is ERP an effective business strategy to pursue? Is a company's position on the strategic grid related to the adoption of ERP? Is a company's position on the strategic grid related to adoption of single-vendor versus best-in-breed strategy?
- What are distinguishing characteristics and difference between adopters and non-adopters?

Outcomes

Finally, there is a need for identifying and measuring the outcomes of ERP implementations not only in terms of conversion success and ERP value, but also with respect to the systems' impact on the culture, strategy, and business processes of the organization. It will be necessary to identify performance measures or system performance indicators (SPI's) that support a successful implementation and can be used to assess the relative position of a system against some standard or reference point, such as an organizational goal (Cave, Hanney, and Kogan, 1991). SPIs should focus on the financial growth impact as well as on the strategic implications of ERP implementations. They should include operational and a

selection of financial and growth measures. Future research may consider using, for example, a representative sample of items from the entire construct domain of operational performance: product quality, employee morale, on-time delivery, inventory management, employee productivity, equipment utilization, production lead time, and scrap minimization which capture both efficiency and effectiveness (Venkatraman and Ramanujam, 1986). Given the complexities of ERP systems and following Motiwalla and Fairfield-Sonn (1998), we suggest adoption of a holistic approach towards measuring conversion effectiveness and ERP value that categorizes measurement criteria on the two dimensions of time (short-and long-term measures) and tangibility (tangible and intangible measures). While the focus of these measures is on intended consequences, an exploration of ERP's unintended consequences may be another fruitful avenue for future research. Following are some specific research questions related to ERP benefits:

- Is there a relationship between implementation strategies and outcomes?
- What constitutes conversion success at the project level versus the organizational level?
- What are differences in benefits between mature and new ERP installations? How do companies track and measure the benefits of ERP?
- Can these benefits be gained by every organization that uses ERP or are there specific conditions that must be present to realize the benefits?
- What impact does ERP have on an organization's performance such as profitability and market share? How do companies without ERP systems compare to companies with ERP systems (e.g. performance, operational efficiencies)?
- How do organizational characteristics contribute to the value ERP adds to the organization?
- How and under what circumstances can ERP add value to an organization's primary activities?
- Which benefits do companies realize from linking ERP systems to the supply chain and customers?
- Is ERP related to the performance of other companies participating in the supply chain?
- What is the impact of ERP system implementation on other IT projects? What are implications for organizational learning?

Conclusions

While ERP was introduced only a few years ago, the speed with which organizations have embraced and implemented the systems has been phenomenal. Unfortunately, ERP implementations have been plagued by high failure rates and difficulties to realize the promised benefits. As our conceptual model indicates, ERP implementations represent high-risk projects that need to be managed properly. Organizations must learn how to identify the critical issues that affect the implementation process and address them effectively to ensure that the promised benefits can be realized and failures can be avoided.

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