To the Graduate Council:

I am submitting herewith a dissertation written by Marianne Bradford entitled "The Implementation of Enterprise Resource Planning: An Innovation Diffusion Approach." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements of the degree of Doctor of Philosophy, with a major in Business Administration.

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ABSTRACT

Enterprise resource planning (ERP) systems have been adopted by many businesses in the past decade. These systems have revolutionized organizational computing by integrating the majority of business processes, sharing common data and practices across the entire enterprise, and producing and accessing information in a real-time environment. Organizations have realized important tangible and intangible benefits from ERPs including general and administrative expense reduction, margin enhancement, revenue growth, improved customer satisfaction, and personnel and information technology (IT) staff reduction. Despite these benefits, many companies have had serious problems implementing ERP systems. These problems have caused many companies to abandon their ERP initiative or implement the system in limited capacity.

This study investigates the implementation of ERP systems by drawing upon research in diffusion of innovation (DOI) theory and information systems. Specifically, this study examines the relationship between certain key factors grounded in DOI theory and the extent of implementation and success of implementation of ERP. Two dimensions of extent of implementation examined are the breadth of implementation, or percentage of company sites using ERP, and depth of implementation, or the number of different ERP components deployed within a company. The model developed includes contextual variables such as innovation characteristics, organizational characteristics, and

environmental characteristics as determinants of the extent of implementation and success of implementation of ERP systems. The data for the study was obtained from a field survey of 51 firms that have adopted ERP systems. Survey respondents are the project managers of ERP implementations within manufacturing organizations.

The results of regression analyses reveal that two innovation characteristics, compatibility and relative advantage, and an environmental characteristic, competitive pressure, are major predictors of breadth of implementation. Additionally, a control variable, size, was significant in the model. The only significant explanation of depth of diffusion is size. Two innovation characteristics, complexity and relative advantage, and one organizational characteristic, top management support, were instrumental in explaining implementation success.

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CHAPTER I

INTRODUCTION

In the early 1990s a quiet revolution began that would eventually alter the status quo of organizational computing. Huge, billion dollar software houses promised a one-stop "meet all your needs" application for managing virtually all facets of an enterprise. These applications became known as enterprise resource planning (ERP) software and were touted by ERP vendors as the answer to any firm's business and information technology (IT)-related issues.[1]

ERP applications are packaged business software systems that enable companies to automate and integrate the majority of their business processes, share common data and practices across the entire enterprise, and produce and access information in a real-time environment (Deloitte Consulting, 1999). ERPs serve as a unifying systems backbone by linking the supply chain of an organization using a shared database and tightly integrated processes. They gather, manage, automate, and share data on all aspects of a company from receipt of materials through shipment to the customer, including accounting, human resources, engineering, market research, purchasing, and production.[2]

Companies adopt ERP solutions for a variety of strategic reasons, including expectations of reduced costs, support of long-term growth, integration of business processes, and improved productivity and customer responsiveness.

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[1] A list of all abbreviations used in this paper and their corresponding meaning is presented in Table 1 of the Appendix. Also included in the Appendix are all other tables and figures.
[2] The ERP market was $15 billion in 1999 and is expected to grow to $50 billion by the 2004. Some estimate that the eventual size of this market will reach $1 trillion (Bingi et al. 1999).

Less strategic reasons for adopting ERP solutions include complying with Year 2000 formats, integrating disparate business units, consolidating redundant proprietary systems, and replacing obsolete systems (Brakely, 1999). Potential benefits from implementing an ERP package include general and administrative expense reduction, margin enhancement, revenue growth, and personnel reduction. Additionally, companies may realize certain intangible benefits such as improved customer satisfaction, finely tuned business processes, and improved visibility of information (Deloitte Consulting, 1999). By implementing a configurable "off-the-shelf" ERP solution, firms can upgrade their business processes to industry standards, taking advantage of many years of business systems reengineering and integration experience of the major ERP vendors (Jenson and Johnson, 1999).[3]

Even though the ERP market has experienced tremendous growth over the last few years, many companies are dissatisfied with their ERP solution. Of all ERP projects undertaken, 50 percent are either shelved due to lack of management or user support, or the projects fail during the implementation process. Of those solutions implemented, 75 percent are subsequently rated poor by users (Fryer, 1999). ERP success stories have been overshadowed by tales of ERP derailments that have attracted media attention over the past few years. Recently, Dow Chemical, after spending $500 million over seven years to implement a mainframe ERP system, has started over again with a client-server

[3] The dominant enterprise systems integrator is SAP with approximately 35% of the ERP market in 1999. Oracle, Peoplesoft, and J. D. Edwards are also among the top vendors.

version. Unisource Worldwide, Inc., a $7 billion distributor of paper products, wrote off $168 million in costs related to an abandoned nationwide implementation of SAP software. Additionally, former $5 billion drug distributor FoxMeyer Health Corporation went bankrupt in 1996 and has filed a $500 million lawsuit against SAP. A company spokesman summed up what FoxMeyer experienced: "The computer integration problems we had were a significant factor leading to the bankruptcy filing" (Jenson and Johnson, 1999).

The large initial cash outlays and negative return on investments (ROI) not only have created lawsuits, but also have caused rampant internal company politics and massive controversy in the popular press. While there are a few success stories, these cases are a "rare occurrence in the world of ERP," maintains Jim Johnson, chairman of The Standish Group, a research advisory firm (Fryer, 1999). With over 90 percent of implementations ending up late or over budget (an estimate The Standish Group calls "conservative"), many companies are questioning where and when they will realize the value of ERP (Fryer, 1999). According to Meta Group, an IT consultancy, it takes an average of 23 months to implement an ERP system, and another 31 months – four and a half years total – to see demonstrable benefits. Over a five-to-six year period the average company incurs a negative net present value of $1.5 million. Only if the implementation is successful will companies realize a positive net present value (Fryer, 1999).

For many firms, other companies' experiences implementing ERP have created a high level of fear about undertaking an ERP initiative. After jumping on the ERP bandwagon, many companies spend millions of dollars in massive implementation projects that include software, consulting and training costs, business process reengineering, systems downtime, and new hardware. Companies can spend several years implementing an ERP package, but if they are not able to roll it out effectively, they stand to lose not only the capital invested in software and consulting fees, but also a major portion of their business (Bingi et al. 1999). The bane of an unsuccessful implementation is that it can severely hurt a firm's short-term profitability and, in some cases, destroy an organization.

A successful ERP implementation can be measured in many ways, using a variety of metrics tied to the business case. However, among various measures suggested by the IS implementation literature, system usage and user satisfaction have been found to be the most common (Delone and McLean, 1992). These two measures have also been found to be important in IS innovation diffusion research (Premkumar et al. 1994; Kwon and Zmud, 1987). User satisfaction is often measured by the degree of perceived implementation success assessed by certain stakeholders of the system including top management, functional managers, and users. According to the IS implementation literature, a system can be considered a success only if it is perceived to be satisfactory and willingly used by key stakeholders (Ramamurthy and Premkumar, 1995).

System usage is often measured by the internal diffusion of the technology within an organization (Delone and McLean, 1992). It has been suggested that one of the important success measures of an ERP implementation is extensive deployment (Donovan, 1999). According to Donovan (1999), only when all departments and business units within a company are completely integrated together under the ERP umbrella, and the package is fully synthesized into day-to-day operations, can a company maximize the potential benefits. However, research suggests that thorough and rapid deployment is the exception rather than the rule for many technologies (Howard and Rai, 1993) and that the processes of diffusion rarely unfold in a smooth and predictable manner (Fichman and Kemerer, 1999). According to Fichman (1999), if organizations always implemented innovations rapidly, adoption timing would be the universal definition of firm innovativeness. However, post-adoption behavior varies considerably among organizations.[4]

This dissertation examines the impact of certain factors, grounded in diffusion of innovation (DOI) theory, which may influence the diffusion process and implementation success of ERP installations. DOI theory classifies these factors into innovation characteristics, organizational characteristics, and environmental characteristics, and postulates that each factor will contribute either positively or negatively to the implementation processes of an innovation.

[4] Chew et al. (1991) report that 50-75 percent of advanced manufacturing implementations experience some kind of failure. Additionally, examples of innovative technologies that failed to diffuse as expected include artificial intelligence (AI) (Gill, 1995), computer aided software engineering (CASE) (Fichman and Kemerer, 1999), and integrated services digital networks (ISDN) (Lai et al. 1993).

The theory of innovation diffusion has been widely applied in research studies, most of which have focused on the adoption of social and scientific innovations by individuals (Tornatzky and Klein, 1982). Recently, this theory has received substantial attention in IT research, providing much insight into the implementation of technological innovations by organizations. Most IT DOI studies have focused solely on what factors affect an organization's tendency to adopt innovations (Tornatzky and Klein, 1982). In these studies, adoption is measured as a "yes" or "no" decision, and no attempt is made to study post-adoption behavior. This approach is criticized because it treats innovation as a single event rather than a continually changing process (Kwon and Zmud, 1987).

According to Kimberly (1981), the failure to measure post-adoption behavior as a dependent variable in innovation studies has been a conceptual and methodological weakness in the literature. In an attempt to improve innovation studies, researchers have begun to extend the process orientation to account for events after companies make the explicit commitment to use an innovation (Palmer, 1998; Premkumar et al. 1994). Therefore, recent research has identified variables related to a firm's degree of implementation (internal diffusion) or some equivalent measure. By examining post-adoption behavior in organizations, this study improves innovation research and contributes to our understanding of the ERP implementation process.

The uniqueness of ERP as an enterprise-wide technological innovation provides fertile ground for an IT DOI study. The majority of research on technological innovations examines innovations with limited corporate-wide prominence, such as computer aided software engineering (CASE) tools, document imaging, budgeting software, and electronic data interchange (EDI). No study has attempted to investigate a technological innovation with such extensive corporate-wide prominence. Furthermore, case studies and practitioner articles have reported varied firm experiences with the deployment of ERP. This variation indicates that a more detailed analysis with a larger sample of firms would provide meaningful insight into the ERP implementation process.

Using DOI theory to study the factors affecting the diffusion of ERP within organizations can provide guidance to practitioners faced with the difficult task of introducing this technology into their firm. Additionally, testing DOI theory in the context of ERP will lend additional support to the development of a unifying theory for IT diffusion, which at this time is lacking in the literature. In the absence of a general theory of innovation, Fichman (1999) suggests that researchers should develop theories of the "middle range" – that is, theories tailored to certain classifications of technologies and/or to particular adoption contexts. Additionally, researchers have realized the importance of building comprehensive models that include more than one set of antecedent variables.

The current study extends information systems (IS) research in three ways. First, this is perhaps one of the first studies to examine the implementation process of ERP from both a theoretical and empirical perspective. Second, the low explanatory power of models in IT diffusion studies suggests that other key variables should be explored. Thus, a more comprehensive model is developed in this study. Finally, the study will advance IS research by assisting in the development of IT diffusion theory.

This study also has implications for practitioners. Because schedule overruns in ERP implementations are a current problem facing many organizations, results prescribing effective practices might provide direct practical benefit to systems consultants and organizational management. Studying the ERP diffusion process also can have implications for companies that experience failed ERP implementations.

The remainder of this dissertation is organized as follows: Chapter II discusses the theoretical background for this study; Chapter III develops the research model and delineates the hypotheses; Chapter IV discusses the study's methodology; Chapter V presents the results and Chapter VI discusses their implications. Finally, Chapter VII presents contributions, limitations, and future research opportunities.

CHAPTER II

LITERATURE REVIEW

The two major areas of research that provide the theoretical foundation for this paper are DOI theory and IS implementation literature. Both DOI theory and IS implementation literature provide rich frameworks in which to study the adoption and implementation of technologies by individuals as well as organizations. Numerous researchers have suggested that functional parallels exist between the two literature streams (Premkumar et al. 1994; Kwon and Zmud, 1987). Viewed from an innovation diffusion perspective, IT implementation is defined as “an organizational effort directed toward diffusing appropriate information technology within a user community” (Cooper and Zmud, 1990). Blending these two theories together into a comprehensive model that investigates the implementation of ERP applications provides a more complete view of the process.

Furthermore, most major organizational change over the last few decades has been technology-driven. The rapid movement of technologies within organizations has raised concern over the capability of organizations to manage the introduction of technology (Kwon and Zmud, 1987). Researchers have stressed that the implementation process is as important for IT implementation success as the IT innovation itself. Therefore, studies should focus on mechanisms that promote innovative behaviors throughout the entire implementation process (Kwon and Zmud, 1987).

DOI Theory

DOI theory has a long history as a multi-disciplinary field, including contributions from economists, sociologists, and organizational and IT researchers. Research based on DOI theory investigates the evaluation, adoption, and implementation of innovations. Rogers (1983), an authority on innovation theory, defined innovation as an idea, practice, or object that is *perceived* as new by an individual or other adopting unit.[5] Innovation is a way of changing an organization, whether in response to changes in the internal or external environment or as a preemptive action to influence the environment (Damanpour, 1991). Diffusion is the process whereby the innovation is spread or disseminated over time to members of a social system (Zaltman et al. 1973).[6] When an innovation is adopted and diffused by a sufficient number of relevant units in a system to register an impact (e.g. become integrated into the normative patterns of the system), social change occurs (Zaltman et al. 1973).

DOI theory involves certain time dimensions. One of these time dimensions is conceptualized as the relative earliness/lateness with which an innovation is adopted compared to other members of a social system. Thus, the *innovativeness* of an organization is measured by its relative earliness in

[5] While ERP systems are not inherently innovative, they can represent innovations to the firms deploying them because they can dramatically alter business practices and the manner in which data is collected, processed, and communicated.

[6] While the term *diffusion* has been used to characterize the dissemination of an innovation among organizations or within organizations, other researchers have used the term *assimilation* to denote the dissemination of innovations within organizations and *diffusion* to denote the dissemination of innovations across organizations (Fichman, 1999).

adopting new ideas compared to other members of a system (Rogers, 1983).[7] Another time dimension is the length of time required to pass through the stages of innovation, or the *innovation-decision process* (Rogers, 1983). This process begins when an individual (or other decision-making unit) progresses from first knowledge of the innovation to forming an attitude toward the innovation, then a decision to adopt or reject the innovation, implementation of the new idea, and finally, confirmation of the decision (Rogers, 1983).

The present study examines the extent of diffusion of ERP within organizations as a function of certain antecedent variables identified in DOI literature. These variables also will be used to investigate firms' implementation success with ERP (Ramamurthy and Premkumar, 1995; Premkumar et al. 1994).

Extent of diffusion has been operationalized different ways in recent IT diffusion studies.[8] IT research suggests that the use of technology has both a "breadth" and a "depth" component (Kosnik, 1990; Rai, 1990). In considering ERP, these two dimensions appear to fit naturally with ERP usage. Breadth of diffusion refers to how widely used a technological innovation is throughout an adopting organization (i.e. how many departments, sites, or employees use the

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[7] A stream of research studies the characteristics of adopter categories, classified by Rogers (1983) as innovators, early adopters, early majority, late majority, and laggards. However, the present study will not attempt to study the specific characteristics of adopter categories.
[8] Thong (1999) measured extent of small business IS adoption as the number of personal computers (PC) and the number of software applications in use. Palmer (1998) measured extent of diffusion of quick response (QR) technology as the number of different types of QR used by an organization. Ramamurthy and Premkumar (1995) measured extent of EDI diffusion as the extent to which it was integrated and used with different types of IS applications in a firm, including delivery tracking, accounts receivable, and customer payment.

technology). Depth of diffusion refers to how many of the technology's features are used in an adopting organization (McGowan and Madey, 1998). The current study will measure both breadth and depth of diffusion, as each is applicable to the ERP implementation process. As in prior research, the satisfaction of key stakeholders of the system proxies as the measure for implementation success (Delone and McLean, 1992; Ramamurthy and Premkumar, 1995).

The following sub-sections elaborate on the current state of IT innovation diffusion research and lays the groundwork for this paper's importance in the DOI research stream. The first sub-section discusses innovation typologies, which differentiate among types of IT innovations. The next section introduces the idea of stage models, which capture the organizational learning process throughout the diffusion process. Finally, the last sub-section describes the different innovation contexts used in this paper to examine the intra-organizational diffusion of ERP systems.

Innovation Typologies

Numerous typologies intended to classify innovations have been advanced in the DOI literature over the years. Recently, researchers have focused their attention on typologies that differentiate IT innovations. Swanson (1994) proposed a typology of IT innovations that classifies technological innovations by locus of impact. According to this typology, IT innovations may be supportive of the IS core, the administrative core, or the technical core. IT innovations that support the IS core are those that support the work processes and decision-making of IS professionals. IT innovations that support the technical core of an organization are those that represent ideas for new products, processes, or services. Finally, IT innovations that support the administrative core of an organization pertain to the structuring of tasks, authority, and reward. While some researchers have found this classification scheme to be useful, Prescott and Conger (1995) noted that the separation of administrative and technical innovations in organizations has become problematic. In many organizations, the administrative and technical cores are closely coupled, and due to reengineering, are merging together. ERP is one such innovation that has characteristics of both technical and administrative innovations because it creates new processes and structures tasks differently. Therefore, this typology, which has been used in prior research, is problematic for classifying ERP.

Because of the aforementioned concerns regarding Swanson's (1994) typology, Prescott and Conger (1995) proposed another classification scheme for IT diffusion. This typology classifies technological innovations according to whether they primarily affect IT personnel (IS unit impact), the entire organization (intra-organizational), or an organization and its external trading partners (inter-organizational). IS innovations include those used internally in systems work groups such as support personnel, application developers, and network administrators. Examples of technology innovations with IS-unit impact are CASE tools and unattended computer-operations environments. Intra-organizational technologies impact one or more units of an organization, but the locus of impact is within the organization. Examples of intra-organizational technologies are distributed database management systems (DDMS) and ERPs. Finally, inter-organizational locus of impact involves multiple companies interacting together. Examples of technologies in this category are EDI networks and ISDN.

Prescott and Conger (1995) argued that recognition of locus of impact in technological innovation diffusion studies is important for the development of a strong theory of IT diffusion. Additionally, Fichman (1999) suggests developing innovation theories of "middle range" before trying to establish a unifying theory of IT innovation diffusion. By designating the locus of impact (intra-organizational) and the type of technology employed (ERP), this study furthers the development of IT diffusion theory by properly positioning itself in the stream of research.

The following section presents the idea of stage models in understanding the innovation-decision process. An innovation stage model is presented, and its correspondence to the ERP implementation process is discussed.

Innovation Diffusion Stages

The innovation process is comprised of a sequence of stages, each characterized by a certain range of events, actions, and decisions made at each point. All stage models of innovation diffusion begin with the initiation of the decision to adopt an innovation followed by progressive stages of diffusion. A model of the ERP implementation process and its relationship to innovation diffusion stages is presented in Figure 1. This model is based on earlier work by Cooper and Zmud (1990) and Hage (1980). The five stages of diffusion are adoption, preparation, implementation, routinization, and infusion. A brief discussion of the various stages of an ERP implementation and their correspondence to the five-stage diffusion model follows.

In the *adoption* stage of diffusion, rational and political negotiations take place to obtain organizational backing for the innovation, and the decision is made to invest resources in the implementation effort (Cooper and Zmud, 1990). This stage is characterized by a high level of uncertainty concerning the innovation's returns (Gosselin, 1997). The investment in ERP system is a careful exercise in divisional and departmental negotiation (Bingi et al. 1999). Companies adopting an ERP system should do so only after developing a detailed business case, which includes anticipated benefits and metrics to track the company's progress along the way. Additionally, during the adoption stage the project team should develop a business model blueprint of what the company will look like after "going live" and commit the best and brightest people to the task of implementation.

Once a firm makes the decision to adopt the innovation, it must develop the infrastructure needed to support it (Gosselin, 1997) and/or modify the innovation to fit the organization's particular situation (Rogers, 1983). This *preparation* stage corresponds to the design and customization phase on an ERP implementation in which business processes are redesigned based on the package's functionality, and the system is configured to reflect the organizational structure depicted in the business model blueprint.

Implementation coincides with the installation stage of an ERP implementation. In this stage, the project team and consultants install and test the software and write any necessary interfaces and conversions. Once the data is converted and the system is turned on, accountability is transferred to user management (Norris et al. 1998). This represents the point of the implementation process known as "going live." The *routinization* stage then occurs as employees are induced to commit to usage of the innovation as a regular part of organizational procedures.

Cooper and Zmud (1990) add a final stage, *infusion*, to the model of IT implementation process. Infusion is the extent to which an innovation's features are used in a complete and sophisticated way (Fichman, 1999). This corresponds to the operate and sustain stage of ERP implementation, which involves consistently reviewing the system, measuring business performance, and identifying action plans for sustaining competitive advantage (Norris et al. 1998).[9]

Stage models assume a linear progression of diffusion. However, organizations may diverge from this progression in two primary ways: by either evaluating and rejecting the innovation or by adopting but later discontinuing use. The next section discusses innovation contexts that serve as classes of antecedent variables in the present study.

[9] Deloitte Consulting (1999) term this last stage the "second wave." While the focus of the ERP implementation process ("first wave") is on "going live" within time and cost constraints, the focus of the "second wave" is on "maximizing, accelerating, and sustaining the fuller benefits of ERP-enabled systems."

Innovation Contexts

In response to the lack of a unifying theory of innovation diffusion, Fichman and Kemerer (1993) argue that it is critical to include the distinctive characteristics of context in the development of a strong theory. Therefore, empirical studies based on DOI theory should include variables representing different contexts found to be related to organizational innovativeness (Damanpour, 1991). Several researchers have attempted to identify these important contexts. While Roger's (1983) innovation theories have been widely accepted in adoption and diffusion research, researchers have drawn upon other contexts, such as voluntariness of use and IS unit sophistication, to provide a richer and potentially more explanatory model (Fichman and Kemerer, 1997; Agarwal and Prasad, 1997). However, based on a meta-analysis of 70 IS-related papers, Prescott and Conger (1995) conclude that Roger's (1983) diffusion of innovation theory appears to be most applicable to intra-organizational innovations. Therefore, the present study incorporates traditional diffusion of innovation contexts to study the diffusion of ERP. These contexts include innovation characteristics, organizational characteristics, and environmental characteristics.

Innovation Characteristics

Rogers (1983) identified certain attributes, or characteristics, of innovations that have systematic effects on their adoption and diffusion. He highlights five such characteristics: relative advantage, compatibility, complexity, trialability, and observability. Since Roger's (1983) seminal work in innovation diffusion, researchers have studied many innovation characteristics.[10] The majority of these studies have focused on adoption of innovations by individuals, and many of the studies include only one innovation characteristic. In a meta-analysis of innovation diffusion studies, Tornatzky and Klein (1982) noted that only three innovation characteristics have possessed consistent associations with innovation behaviors: compatibility, relative advantage, and complexity.

Compatibility refers to the degree to which an innovation is perceived as consistent with an organization's existing technical systems, operating practices, values, and beliefs (Rogers, 1983). The more compatible an innovation is with present systems, procedures, and values, the more likely the innovation will diffuse throughout a company. Relative advantage is the degree to which an innovation is perceived as better than the innovation it supersedes (Rogers, 1983). The more positive the firm members' perceptions of the benefits to be derived from an innovation, the greater the chance of it diffusing successfully. Complexity refers to the difficulty of understanding, using, and implementing an innovation (Rogers, 1983). The more complex an innovation is perceived, the greater the difficulty of diffusing it.

Damanpour (1991) recommended including innovation characteristics in studies involving a single innovation. Additionally, Tornatzky and Klein (1982) emphasized the importance of comparing several innovation characteristics within the same study. Therefore, innovation characteristics of compatibility, relative advantage, and complexity are included in the present research.

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[10] Innovation characteristics studied in prior research are presented in Table 2.

Organizational Characteristics

Organizational characteristics are another context included in the present study's model. Organizational theorists have proposed that more "mechanistic firms" (e.g. those with higher centralization and formalization) should have less difficulty diffusing innovations because they are better able to establish the kind of consensus and singularity of purpose needed to sustain implementation (Zaltman et al. 1973; Zmud, 1982; Rogers, 1983). The results of studies testing this assertion have been mixed, and it is suggested that more research is needed to ascertain the importance of a mechanistic structure on the diffusion of technologies (Fichman, 1999).

The complexity of an organization is another factor that may affect the diffusion of innovation (Rogers, 1983). Organizational complexity is the degree to which an organization's members possess a relatively high level of knowledge and expertise. In many studies, this variable has been operationalized as horizontal differentiation, or the number of different departments or divisions in a company.[11] Meyer and Goes (1988) found that technological innovations diffuse more extensively in hospitals that exhibit complex structures and pursue aggressive market strategies. Other research has found that technological innovations diffuse less extensively in complex organizations (Damanpour,

[11] The rationale behind horizontal differentiation affecting the diffusion of ERP is that problems of coordination and control are exacerbated when organizations are formally divided into large numbers of functional units. A horizontally differentiated organization creates multiple interest groups and multiple demands for elaboration of the core technology (Kimberly and Evanisko, 1981).

1991). In the absence of a persuasive theory regarding the effects of organizational complexity on the diffusion process, more research is warranted.

Environmental Characteristic

The environment of a firm consists of those relevant physical and social factors outside the boundaries of the firm that can affect management decision-making. Components comprising an organization's environment are suppliers, customers, regulatory groups, and competitors (Zaltman et al. 1973). The influence of an organization's environment is the context least researched in innovation diffusion studies (Prescott and Conger, 1995), although assertions regarding its influence frequently appear (Kwon and Zmud, 1987; Thong, 1999). With the recent interest in IT innovation diffusion, this line of research is becoming increasingly important, and Prescott (1995) urged researchers to pay closer attention to environmental impacts to gain additional understanding of IT diffusion.

Fichman (1999) identified competitive pressure as an environmental variable that can influence the general propensity of an organization to innovate. According to Thong (1999), tough rivalry pushes organizations to be innovative. In today's competitive corporate environment, it is clear that IT is no longer viewed as merely supporting the enterprise. The role of IT has become much more dominant from both a strategic and an operational perspective (Jenson and Johnson, 1999). Many companies have realized the need to have real-time information that can be shared throughout the organization. They are adopting an ERP as a strategic solution and are doing so out of competitive necessity.

CHAPTER III

RESEARCH MODEL AND HYPOTHESES

The conceptual model is outlined in Figure 2. This model is comprised of three classes of factors: innovation characteristics, organizational characteristics, and environmental characteristics. Based on past research in DOI theory and IS implementation theory, these factors are linked to systems usage, or extent of implementation, and implementation success, or perceived system stakeholder satisfaction.

Two general research questions emerge from this model: (1) What variables influence the extent of implementation (breadth and depth of diffusion) of ERP applications within firms? and (2) What variables lead to a successful ERP implementation (high stakeholder satisfaction) in firms?

Innovation Characteristics

Compatibility

According to Rogers and Shoemaker (1971), the compatibility of an innovation is the extent to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of the recipient. Schultz and Slevin (1975) identified two types of compatibility: organizational and technical. Organizational compatibility refers to whether the innovation is compatible with existing norms, values, and beliefs of the adopting unit. Technical compatibility refers to the innovation's compatibility with existing systems, including hardware and software.

The current study hypothesizes that both aspects of compatibility influence the extent of diffusion and implementation success of ERP for the following reasons. An ERP system typically stimulates the most traumatic change an organization ever encounters because of the extensive reengineering that inevitably occurs. The more foreign the system is to current practices, the more complex and time consuming the configuration process will be, and the more entrenched organizational resistance becomes. Additionally, it is likely that existing hardware and legacy software, which are technically incompatible with the system, will be integrated with the ERP. The closer the fit with the organization's existing systems and operating practices, the more likely the ERP solution will be extensively diffused and the implementation considered a success. Based on this rationale, the following hypotheses are postulated:

H1a: Compatibility of ERP with existing technical systems and organizational beliefs will be positively associated with breadth of ERP diffusion.

H1b: Compatibility of ERP with existing technical systems and organizational beliefs will be positively associated with depth of ERP diffusion.

H1c: Compatibility of ERP with existing technical systems and organizational beliefs will be positively associated with the implementation success of ERP.

Relative Advantage

Relative advantage is the degree to which an innovation is perceived to provide greater organizational benefits than either other innovations or the status quo (Rogers, 1983). These benefits may be tangible or intangible. Considering ERP, most firms develop a business case to justify their adoption of an ERP package. This business case sets forth the relative advantages of the ERP over the status quo or other system solutions and includes metrics and benchmarks that will be evaluated throughout the implementation process.

A recent study indicated that some of the major benefits that can accrue to firms adopting ERP are inventory reductions, personnel reductions, productivity improvements, IT cost reductions, improved order management and cycle times, improved cash management, and reduced costs in procurement (Deloitte Consulting, 1999).

Most DOI research has inferred relative advantage instead of gathering this information via surveys or interviews. Additionally, most DOI research investigates an individual adoption decision rather than an organizational decision (Tornatzky and Klein, 1982). Premkumar et al. (1994) found relative advantage to positively influence the diffusion of EDI. Thong (1999) also found that relative advantage was associated with extent of small business diffusion of personal computers (PCs). Likewise, it is believed that relative advantage will be positively associated with the implementation processes of ERP. Thus, the following hypotheses are postulated:

H2a: Relative advantage will be positively associated with breadth of ERP diffusion.

H2b: Relative advantage will be positively associated with depth of ERP diffusion.

H2c: Relative advantage will be positively associated with the implementation success of ERP.

Complexity

Complexity is the degree to which an innovation is perceived as being difficult to understand and use (Rogers, 1983). Although an innovation may seem useful, the organization may not have the expertise necessary to assimilate it.[12] Companies that perceive ERP to be a complex business solution will tend to diffuse it slowly and in limited capacity. A common theme in ERP anecdotal literature is the steep learning curve inherent to ERP systems. Some companies, such as Owens Corning, make employees pass a test before using the system because of the vast potential for human error and the impact errors have on all aspects of the company.

Most DOI research focuses on the relationship of complexity to the adoption of innovations by individuals (Tornatzky and Klein, 1982). Studies that explore the relationship of an innovation's complexity to diffusion have shown mixed results (Ramamurthy and Premkumar, 1995; Thong, 1999). Thus, more research

[12] Complexity is similar to perceived ease of use, which is the degree to which a particular system is perceived to be relatively free from physical and mental effort (Davis, 1989).

is needed to understand complexity's influence on the diffusion process of technological innovations.

It is also suggested that the perceived complexity of an innovation leads to resistance due to lack of skills and knowledge (Rogers, 1983), and organizational resistance of technologies leads to a lower user satisfaction (Tornatzky and Klein, 1982). Thus, the following hypotheses are postulated:

H3a: An innovation's complexity will be negatively associated with breadth of ERP diffusion.

H3b: An innovation's complexity will be negatively associated with depth of ERP diffusion.

H3c: An innovation's complexity will be negatively associated with the implementation success of ERP.

Organizational Characteristics

Mechanistic Structure

A mechanistic organizational structure is one that exhibits high centralization and formalization, and an organic structure exhibits the opposite characteristics. Centralization represents the concentration of decision-making authority in the hands of a relatively few individuals (Rogers, 1983). In firms with high centralization, communication channels are highly structured and a strong emphasis is placed on holding fast to management direction. Formalization is the degree to which an organization emphasizes following rules and procedures in the role performance of its members (Rogers, 1983). Firms with high formalization have explicit job descriptions, many rules, and clearly defined procedures covering work processes (Robbins, 1983).

In an ERP implementation, it is expected that a mechanistic structure will encourage extensive deployment because of the control necessary to drive the change management process. According to Jenson and Johnson (1999), successful enterprise systems implementations require a high degree of discipline from organizations. Firms not accustomed to this level of discipline will struggle with such a comprehensive intervention. The more an organization relies on formal rules and procedures during the implementation, the more controlled the process will be. The more controlled the implementation, the more satisfied users will be with the process. Thus, the following hypotheses are postulated:

H4a: A mechanistic organizational structure will be positively associated with breadth of ERP diffusion.

H4b: A mechanistic organizational structure will be positively associated with depth of ERP diffusion.

H4c: A mechanistic organizational structure will be positively associated with the implementation success of ERP.

Organizational Complexity

According to Rogers (1983), the complexity of an organization encourages firm members to conceive and propose innovations, but it could make it difficult to reach a consensus about how to implement them. Studies have operationalized organizational complexity different ways.[13] By far, the most

[13] In their study of the diffusion on technological innovations in hospitals, Meyer and Goes (1988) used the availability of distinct medical services as a measure of complexity. Kimberly and Evanisko (1981) used functional differentiation, or the extent to which an organization is divided

common measure of organizational complexity is horizontal differentiation, or the number of departmental units within a company. In an ERP implementation, the appropriate measure for organizational complexity is the number of company sites involved in the implementation. The more sites involved in the implementation, the more complex the process becomes. Furthermore, the more sites involved, the harder the coordination between business units and the more difficult the integration of the package.

Because the implementation process may take more time in a complex organization, satisfaction of users will most likely be lower. Many consultants stress the importance of rapid deployment of ERP. According to Mike Mohrman, ERP executive at IBM, "Implementing an ERP faster makes the system better; otherwise, lethargy sets in and people lose interest in the project" (Baer, 1998). Michael Hammer, one of the leading experts in reengineering, states "There is no such thing as slow major change. If you drag major change out an extended period of time, people get tired, and the project loses credibility. You have to move fast, which means you have to be prepared to make the tough decisions and make them quickly" (Hammer, 1998). Companies too often place inordinate emphasis on risk avoidance and employ an ERP in a low-sales region or country. In the short term, this strategy can shield the company from risk, but in the long run it hinders employee morale and return on investment (Brakely, 1999). Thus, the following hypotheses for organizational complexity are postulated:

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into a number of subunits. Gosselin (1997) measured vertical differentiation to refer to the depth of structure, or number of hierarchical levels below the chief executive officer.

H5a: Organizational complexity is negatively associated with breadth of ERP diffusion.

H5b: Organizational complexity is negatively associated with depth of ERP diffusion.

H5c: Organizational complexity is negatively associated with the implementation success of ERP.

Top Management Support

The active support from top management can positively affect the implementation process of technological innovations (Alexander, 1989; Rai, 1990). It is expected to be even more critical during ERP implementations because, unlike other innovations studied, ERP extends across all functional areas, integrating data from throughout the organization. Not only must management approve the commitment of resources, but they must also be involved in effecting changes to organizational procedures and structure (McGowan and Madey, 1998). According to Laughlin (1999), the first order of business in an ERP initiative is to gain full commitment from senior executives. The active involvement, vision, and direction of high-level executives provides the impetus needed to sustain the implementation of ERP. Additionally, top management support is needed to send clear signals to various parts of the organization about the importance of a project.

As part of the ERP deployment, many companies undergo significant alterations to business practices (Bingi et al.1999). Not only must management fund the project, but they also must take an active role in change management. A review of successful ERP implementations suggests that a smooth rollout involves an effective top down change management process. Although Ramamurthy and Premkumar (1995) did not find that top management was crucial for EDI implementation, it is expected that this variable will be highly related to ERP diffusion because of the aforementioned reasons. Thus, the following hypotheses are postulated:

H6a: Top management support is positively associated with breadth of ERP diffusion.

H6b: Top management support is positively associated with depth of ERP diffusion.

H6c: Top management support is positively associated with the implementation success of ERP.

Business Process Reengineering

The ERP literature stresses the importance of changing business processes to mirror best practices of ERP software. According to Jenson and Johnson (1999) most problems with implementing an ERP result from users trying to map a previously ill behaved system to work with the structure of the ERP. Structural changes are necessary to maximize the benefits from the implementation (Menezes, 1999). To get the most from an ERP installation, companies must move from department-centered to process-centered architecture. The failure to do so will lead to a tardy implementation with most of the benefits left on the table.

ERP packages are built around best practices in specific industries. However, the software may not necessarily fit the operating practices of an adopting firm. In those cases, the package is either custom coded to better suit the firm's needs, or the firm changes its business processes to conform to the package (i.e., process change). Most experts agree that customization of the software results in higher implementation costs and longer implementations. Therefore, companies should keep the ERP system "as is" as much as possible and instead reengineer their business processes to conform to the package (Bingi et al. 1999). Additionally, longer implementations are a key reason for dissatisfaction among key stakeholders of the system. Based on this rationale, the following hypotheses are postulated:

H7a: Business process reengineering is positively associated with breadth of ERP diffusion.

H7b: Business process reengineering is positively associated with depth of ERP diffusion.

H7c: Business process reengineering is positively associated with the implementation success of ERP.

Environmental Characteristic

Competitive Pressure

Competitive pressure to diffuse technologies refers to influences from the organizational environment. To be successful in the global marketplace, companies must integrate business units along with supply-chain activities. This benefits companies in many ways, including quick reaction to competitive pressures (Jenson and Johnson, 1999). Robertson and Gatignon (1986) found that the more competitive a firm's market, the more extensive the diffusion of technologies. Additionally, they found that uncertainty in the market is positively associated with adoption of innovations. Thong (1999), however, found no relationship between competition and extent of diffusion of IS in small businesses.

The majority of studies examining the relationship of competitive pressure to technology diffusion focus on inter-organizational innovations such as EDI (Reekers and Smithson, 1994; Iacovou et al. 1995; Bensaou and Venkatraman, 1996). The impact of competitive pressure on the diffusion of intra-organizational innovations is a relatively unexplored area. In the current study, it is expected that competitive pressure will be associated with extensive diffusion of ERP because ERP facilitates the integration of business units and processes thus enabling companies to obtain a competitive and strategic advantage (Jenson and Johnson, 1999). However, it is not expected that competitive pressure will have any association with implementation success. Thus, the following hypotheses for competitive pressure are postulated:

H8a: Competitive pressure is positively associated with breadth of ERP diffusion.

H8b: Competitive pressure is positively associated with depth of ERP diffusion.

H8c: Competitive pressure is not associated with the implementation success of ERP.

Control Variables

Firm Size

Firm size is employed as a control variable as suggested by Fichman and Kemerer (1997) and Rogers (1983). Regardless of the stage of diffusion, this variable has been linked to organizational innovativeness, although Tornatzky et al. (1983) have argued that size *per se* has no compelling rationale linking it to any innovative activities. They suggest that size proxies for other variables such as education and professionalism, specialization, scale, or slack resources. Regardless of the variable that size proxies for, it must be controlled for in any DOI study (Fichman, 1999).

Elapsed Time

The second control variable employed in this study is the number of years since adoption. This variable is included to capture the variation due to timing issues (Foster and Swenson, 1997). Most innovation diffusion studies essentially take a snapshot in time of organizations' implementation of innovations. However, the earlier that firms begin implementation, the farther along they may be at the time of a diffusion study. With greater diffusion of the technology, more organizational learning takes place and the greater the chance of the innovation spreading throughout the rest of the company. Elapsed time has been found to be important to organizational learning and satisfaction of complex systems (Ramamurthy and Premkumar, 1995).

A list of the factors identified within each context, along with their reference sources and relationship to diffusion and implementation success, is presented in Table 5.

CHAPTER IV

RESEARCH METHODOLOGY

The unit of analysis for this study is a specific ERP project. While some firms elect to undertake ERP projects firm wide, other organizations allow independent strategic business units (SBU) to make the decision regarding adoption and implementation of business applications. Therefore, depending on the manner of ERP deployment, either a specific SBU or an entire company serves as a sample response.

Because the majority of ERP installations have been conducted in manufacturing firms, only those firms are surveyed. Additionally, including only manufacturing firms in the study can control for the potential that certain modules may not be applicable to other types of companies (such as Plant Maintenance or Materials Management). Furthermore, only SAP installations are included in this study. The reason for limiting the study to SAP implementations is the potential for introducing measurement error in diffusion if more than one package were chosen. Every ERP application consists of multiple modules, each with slightly different functionality. Including firms with varying brands of ERP products would weaken the study's internal validity. Finally, each software vendor has a distinct implementation methodology, which could further confound the results.

Empirical tests of the hypotheses were performed using a survey emailed to randomly selected members of America's SAP User Group (ASUG). Although limitations of surveys have been well documented (Young, 1996; Birnberg et al.

1990), this method was the only feasible means to collect the large amount of cross-sectional data needed for this study.

To establish readability and content validity, the questionnaire was pilot tested with SAP project managers in several different organizations prior to administration (Straub, 1989). Additionally the instrument was discussed in depth with two ERP consultants using detailed telephone interviews lasting one hour each. Feedback from pilot testing was used to refine the format of the questionnaire items by addition, removal, or rephrasing of items as necessary.

Survey respondents were SAP project managers or top IT professionals who were well positioned to give complete and accurate insight into the diffusion process of ERP. Contacts were made at the ASUG annual conference and a token gift was given in exchange for an agreement by each respondent to complete the questionnaire at a later date. To provide further incentive, a benchmarking study was promised to each survey respondent.

Of approximately 65 SAP project managers/IT professionals contacted, 51 completed the survey instrument and returned by either email or fax (a response rate of 78 percent). Follow-up emails were used at regular intervals to remind those persons contacted. Because of the intricacies of the questionnaire, face-to-face or telephone interviews were conducted with each respondent following receipt of the completed survey. The sample represented either entire companies or SBUs depending on the nature of deployment within an organization.

A profile of the responding firms is shown in Table 6. The values in the table reveal that responding firms span a wide range of industries, sizes, and years of experience with ERP.[14] The sample represents a wide distribution of company sizes ranging from 200 employees to 200,000. Most of the sample companies have fewer than five years of experience with ERP, which accurately depicts the overall population of ERP clients. Many companies began the implementation of ERP several years prior to Year 2000, allowing enough time to replace legacy systems that were not compliant. Therefore, the number of software systems that needed replacement affected the year implementation began. The sample characteristics are diverse enough that generalization of this study to a wider cross section of the population is possible.

Operationalization of Variables

The survey used in this study is presented in the Appendix. Standard instruments were used as much as possible. Instruments employed in this study were chosen because of their high reliability and validity and the ease with which they can be manipulated to the specifics of this study. Each variable was measured with multiple indicator items to strengthen construct validity.[15] The mean of scores over all questions provided the composite score of that variable. Most items were measured with a seven point Likert-type scale ranging from Strongly Disagree (1) to Strongly Agree (7).

The innovation characteristic of compatibility was adapted from Ramamurthy and Premkumar (1995). In that study, technical compatibility was

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[14] Years of experience with ERP is measured by the time since adoption (i.e., when top management formally commits to invest the necessary resources into the SAP initiative).
[15] Composite scores capture more of a construct's multidimensionality than do individual questions.

measured with one item ascertaining the compatibility of a system with existing hardware and software. Because of the apparent dual dimensionality of this question, the item was separated into two questions in the current study: one measuring compatibility of hardware required to run ERP with existing firm hardware and one measuring compatibility of ERP with existing software. The third item included in the compatibility scale was organizational compatibility in terms of values and beliefs. This aspect of compatibility was measured with one item adapted from the same study. The three items comprised the compatibility scale.

Eight indicators that assess the tangible and intangible benefits of ERP measured relative advantage. This operationalization of relative advantage is similar to that used by Ramamurthy and Premkumar (1995), although the expected benefits of ERP are different than those expected from EDI. The eight indicator items used in this study were those found by Deloitte and Touche (1998) and other sources (Laughlin, 1999; Stenbeck, 1999) to be the most significant and relevant with respect to ERP.

The four-item complexity scale was adapted from Moore and Benbasat (1991). This scale was chosen because of its high reliability, validity, and brevity and measures the perceived complexity of the ERP application.

A firm's mechanistic/organic organizational structure was assessed using Khandalla's (1977) management philosophy scale. This scale has been used extensively in organizational research and has high reliability and validity.

The log of the number of sites involved in the implementation, or horizontal differentiation, measured organizational complexity.[16] This variable was assessed with one question asking the scope of the ERP project across the organization.

The log of the number of employees measured firm size. In organizational research, specifically innovation diffusion studies, size is measured similarly (Zmud, 1982; Kimberly and Evanisko, 1981; Fichman and Kemerer, 1997). The number of employees corresponds to the specific sampling unit (i.e., depending on the nature of the rollout, a specific SBU within a firm or an entire firm may represent the sampling unit).

The extent of competitive pressure, an environmental characteristic, was ascertained by using three questions developed by the author based on earlier work by Thong (1999).

Both breadth and depth dimensions of the diffusion of a technology are measured as suggested by Kosnik (1990) and Rai (1990). Breadth of diffusion refers to how widely a technological innovation is used throughout the adopting organization. Prior research has operationalized breadth by the proportion of employees using a technology (McGowan and Madey, 1998). For the current study, a more reliable measure for breadth of diffusion of ERP is the percentage of implementation sites that have "gone live" with a particular ERP component to

[16] Taking the log reduces the variance in the distribution of the values of size across observations. When the values of one variable are highly skewed – as is often the case with size – the magnitude of its resulting correlation with other variables can be greatly affected by extreme scores (Kimberly and Evanisko, 1981).

total sites involved in the implementation.[17] Adoption of ERP is not an individual employee decision; thus, measuring percentage of employees using ERP is not a valid dependent measure. Additionally, ERP applications are installed across a company network, so entire departments and sites "go live" at once.

To obtain the proportion, project managers were asked the percent (ranging from zero to 100 percent) of company sites that had "gone live" with each SAP module component. Each percent was then entered into a statistical package as a decile from zero to ten (i.e., entering a "2" for "FI" (Financial) would mean that 20 percent of plant sites had gone live with that module). Next, the dependent variable, BREADTH, was calculated by totaling all the percentages across the 26 SAP components.[18] A firm (or SBU) was considered to have high breadth of diffusion the greater this dependent measure total.

Depth of diffusion refers to how the technology is used in an adopting organization. The more purposes it is used for, the higher the depth of diffusion. As an example operationalization of this construct, McGowan and Madey (1998) suggest that depth of EDI diffusion could be measured by the percentage of invoices processed with EDI. In the present study, depth of diffusion was measured by counting the number of SAP components adopted by a firm (or SBU). A module was considered used if any percentage of sites was noted on the survey as having "gone live" with a particular SAP component. The DEPTH count did not include any future plans for components or any components not

[17] The components of SAP (the leading ERP vendor) are presented in Table 3 of the Appendix.
[18] A list of all variables abbreviations used in this paper and their corresponding meaning is presented in Table 4.

adopted. A firm (or SBU) was considered to have high depth of diffusion the greater this dependent measure total.

Elapsed time was calculated by subtracting a company's SAP adoption date from 2000.5 to arrive at the variable ELAPSE.[19] Similar to Krumwiede (1999), time of adoption was defined as the point when approval was granted to devote the necessary resources to implement SAP. Another question, implementation timing, was included in the survey to ensure that respondents answered the question correctly.[20]

Implementation success was measured with three items assessing the perceived satisfaction of the major stakeholders to the system. The IS literature argues that systems can be perceived as successful only if they are satisfactory and willingly used by key stakeholders. Perceptions of success with ERP are extremely important because it is highly integrative and spans across all functional boundaries. Similar to Premkumar et al. (1994) key stakeholders of an ERP system include users, functional management, and top management.

Validity and Reliability

The research variables were tested for various validity and reliability properties. Psychometric theory claims that measurement of all constructs must be reliable and valid to be useful and achieve stable results. One measure of validity, content validity, is evaluated by showing how well the content of a scale samples the subject matter about which conclusions are to be drawn. Content

[19] The study took place in June 2000. This date was converted to 2000.5 for statistical analyses.
[20] Adoption of an ERP system occurs prior to implementation.

validity was established by adapting measures from previous studies and extensively pretesting the instrument with SAP project managers and consultants. Construct validity was evaluated by investigating what qualities a scale measures, that is, by determining the degree to which certain explanatory concepts or constructs account for the performance of a scale. Construct validity was assessed by both convergent and discriminant validity. Convergent validity measures whether items cluster on the theorized factors, while discriminant validity measures the degree to which each construct differs from other constructs and does not correlate highly with other constructs that it should theoretically differ.

Both convergent and discriminant validity properties were assessed using Principal Components factor analysis with VARIMAX rotation. Convergent validity was evaluated by examining if the questions loaded on the theorized factors. Only eigenvalues of 1.0 and above were considered valid factors. The scree plot was also examined to substantiate the number of factors extracted. Discriminant validity was assessed by examining the rotated component matrix to ensure that items did not cross-load on multiple factors. To provide further evidence, two other factor analytic techniques, Maximum Likelihood and Image, were employed and the same factors emerged.

Because relative advantage and management philosophy scales were grouped separately on the survey instrument as independent scales, the items comprising those scales were analyzed together. The remaining items measuring complexity, compatibility, business process reengineering, top management, and competitive pressure, were analyzed together. The results of the latter factor analysis indicated that a five-factor solution was the most likely as only five factors had eigenvalues greater than 1.0. The associated scree plot also showed a leveling off at five factors, thus further substantiating the solution. The rotated factor matrix was examined for items that either did not load strongly on any factor (<0.40) or loaded strongly on more than one factor. The results showed that a priori assumptions were substantiated as five clear factors emerged: COMPLEX, TOPMGMT, BPR, COMPAT, and PRESSURE.

The results for relative advantage revealed that the eight items split into two separate factors representing two types of ERP benefits. A similar result was found by Premkumar et al. (1994), although they chose to combine the items together citing sufficient theoretical justification. In the current study, however, the two factors that emerged from the relative advantage scale clearly represented two facets of ERP benefits. One factor measured improved productivity in various functional areas, and the second factor measured reductions in employees and IT costs. Because of the high loadings on two separate constructs and high face validity, relative advantage was treated as two distinct constructs, each measuring a specific type of ERP benefit.[21]

The scale measuring organizational structure (Khandalla, 1977) also split into two separate factors. Douglas and Judge (2000) found a similar result.[22]

[21] Another benefit of splitting relative advantage into two separate constructs is the added information that can be obtained in subsequent analyses of the variables.
[22] Douglas and Judge (2000) found that only five of the seven items loaded strongly onto two factors, while the current study finds that all seven items load strongly on the two factors.

The first four questions and the last three questions loaded highly on two separate factors. Upon inspection of the questions comprising the two constructs, it was apparent that the first four questions measured centralization, while the last three questions measured formalization. Both centralization and formalization are aspects of a mechanistic/organic structure and could theoretically be treated as separate constructs.[23] Therefore, the two scales that emerged were considered as two separate antecedent variables in the current study.

The test of convergent validity using Principal Components analysis is shown in Table 7. The table also presents the standardized Cronbach alphas, eigenvalues, variances, and cumulative variances explained by each construct. Calculating the Cronbach alpha coefficient assesses the reliability, or internal consistency of the research variables. All of the variables have high factor loadings on their respective constructs (> 0.40), and the reliabilities for each construct are above the generally accepted guideline of 0.50 to 0.60 as suggested by Nunnally (1978). Based on the extensive examination of the psychometric properties of the scales, it is concluded that each variable represents a reliable and valid construct.

[23] Rogers (1983) references centralization and formalization as two components of a mechanistic/organic organizational structure.

CHAPTER V

RESULTS

Correlation Matrix

The correlation matrix of the antecedent variables is presented in Table 8. Of the 55 possible correlations, only 13 are significant. None of the correlations approach 0.80, which would suggest a problem with multicollinearity among the research variables (Hair et al. 1995). The highest correlation is 0.599 between RELADV2 and PRESSURE. This finding suggests that those firms that are aware of the potential benefits of ERP regarding reductions in IT costs and employees sense more competitive pressure to implement the technology. By being aware of the benefits other firms (including competitors) are realizing from adopting an ERP, these firms perceive a competitive disadvantage if they do not follow suit.

COMPLEX is significantly correlated with COMPAT (-.469), RELADV1 (-.303), RELADV2 (-.287), CENT (-.368), and TOPMGMT (-.278). Firms that perceive ERP as difficult to learn also consider it to be highly incompatible with existing values, beliefs, and technical systems. Likewise, firms that perceive ERP as difficult to learn do not view the system as having advantages over their former system. The negative correlation between CENT and COMPLEX suggests that firms that experience difficulty learning SAP have an organizational philosophy that encourages employee decision-making with limited top management control. Perhaps greater top management control aids in the learning process of an ERP. Finally, TOPMGMT is negatively related to COMPLEX, suggesting that upper management's active support of the ERP initiative affects the organizational learning process of the technology. Firms that considered SAP complex had low support and commitment from top management.

The correlation between RELADV1 and RELADV2 is both expected and in the proper direction since the two constructs comprised one-factor scales originally. Centralization and formalization are both aspects of a mechanistic/organic organizational structure and have been found to be highly correlated in prior research (Gosselin, 1997). The two variables also comprised a one-factor scale originally.

Finally, SIZE is positively related to ORGCOMPLEX and RELADV1. The relationship of SIZE to ORGCOMPLEX is not surprising, as larger companies will have more sites involved in an ERP implementation. The relationship of SIZE to RELADV1 suggests that larger firms believe that an ERP solution will provide more productivity benefits in functional areas than will smaller firms. This result could be due to the fact that larger firms have more slack resources than do smaller firms and thus can mobilize the resources required for implementing more ERP components. The relationship between size and diffusion of ERP is tested in the next section.

Hypotheses Testing

Inspection of the data indicates that breadth and depth of diffusion exhibit binary characteristics. For depth of diffusion, firms had either "gone live" with a particular module (100 percent diffusion) or had just begun implementation (zero percent diffusion). Similarly, for breadth of diffusion firms either had implemented many ERP components or had only implemented a few. Therefore, to examine extent of ERP diffusion, binary logistic regression was deemed the most appropriate statistical method for this particular data set.

For the binary logit analysis, BREADTH and DEPTH variables were both calculated by splitting the data at the mean and assigning a probability of one for high breadth and depth and zero for low breadth and depth. The variables entered into Forward Stepwise (Likelihood Ratio) logistic regression comparing high versus low breadth of diffusion were COMPAT, COMPLEX, RELADV1, RELADV2, CENT, FORM, ORGCOMPLEX, PRESSURE, BPR, TOPMGMT, SIZE, and ELAPSE. The following equation presents the final research model for breadth of diffusion (BREADTH):

$$\mathrm{Ln}\,[\mathrm{Prob}(Y = 1)/(1-\mathrm{Prob}(Y = 1)] = \beta_0 + \beta_1(\mathrm{COMPAT}) + \beta_2(\mathrm{RELADV1}) + \beta_3(\mathrm{RELADV2}) + \beta_4(\mathrm{PRESSURE}) + \beta_5(\mathrm{SIZE})$$

Table 9 reports the results of the binary model. As shown, COMPAT, RELADV1, RELADV2, PRESSURE, and SIZE are highly significant. These factors appear to be important determinants in breadth of ERP diffusion. The model's overall predictive accuracy of 85 percent is far higher than the naïve model of 57 percent, suggesting a very good fit.[24] The Cox and Snell and Nagelkerke Indexes, which are analogous to multiple regression R^2, are 0.569

[24] The naïve model is based on the sample of 40 with 23 (57 percent) high breadth and 17 (43 percent) low breadth.

and 0.762 respectively. These measures also suggest a good fit for the model. Table 10 reports the Wald score and the significance of each of the other variables if added to the final model (Table 9). None of the variables was near significance at the 0.05 level.

Next, the same variables were entered into the DEPTH model. This model tested how the variables affect the number of different ERP components used by companies. The following equation presents the final research model for DEPTH.

$$\mathrm{Ln}\ [\mathrm{Prob}(Y = 1)/(1\text{-}\mathrm{Prob}(Y = 1)] = \beta_0 + \beta_1(\mathrm{SIZE})$$

Table 11 reports the results of the binary model. SIZE is the only significant variable in the model. The model's overall predictive accuracy of 68 percent is not as high as that of BREADTH, but is still much higher than the naïve model of 53% percent, suggesting a good fit.[25] The Cox and Snell and Nagelkerke Indexes, 0.283 and 0.378 respectively, are not as high as the BREADTH model but still suggest a good fit for the model. Table 12 reports the Wald score and the significance of each of the other variables if added to the final model (Table 11). Elapsed time (ELAPSE) is the only other variable in the model near significance at the 0.05 level.

A linear regression model was used to the test the relationship of the 12 independent variables and ERP implementation success (satisfaction with the

[25] The naïve model is based on the sample of 40 with 21 (53 percent) high depth and 19 (47 percent) low depth.

system). The results of the stepwise regression shown in Table 13 indicate a significant R^2 of 0.618, which suggests a good model. Three variables were found to be significant in the model: COMPLEX, RELADV1, and TOPMGMT. While COMPLEX is has a negative coefficient, TOPMGMT and RELADV1 have positive coefficients. These findings support the predictions of the model. Furthermore, all of the variance inflation factors for the three significant variables were close to one, which suggests that multicollinearity is not a problem. Table 14 shows the p-values for the excluded variables. Only one variable, CENT, approached significance at the 0.05 level.

CHAPTER VI

DISCUSSION

Table 15 summarizes the results of the key determinants of breadth and depth of diffusion and implementation success. The following is a discussion of the findings of the paper.

Breadth of Diffusion

Breadth of diffusion refers to how widely a technological innovation is used throughout the adopting organization. This dependent variable was calculated by summing the percentages of plant sites that have "gone live" with each SAP component. Five variables were found to be significant in explaining breadth of diffusion in the proposed model: compatibility, relative advantage in terms of increased productivity, relative advantage in terms of reduced costs, competitive pressure, and size. While compatibility, relative advantage in terms of reduced costs, and size (a control variable) were in the hypothesized direction, relative advantage in terms of increased productivity and competitive pressure were in the opposite direction.

As expected, the greater the compatibility of ERP with existing technology and value systems, the more it will be diffused throughout an organization (or SBU). If the ERP solution is compatible with the system as a whole, management will not merely deploy it to a low sales region or limit it to a certain area of the country. The entire organization or SBU will diffuse the application. One of the key components to a winning implementation according to Laughlin (1999) is management driven change. If management can align IT solutions introduced in their firm with firm operating practices and beliefs, the diffusion of the technology will be less difficult. Additionally, the introduction of an ERP in firms creates demands for interfaces with legacy systems and in some cases requires firms to invest heavily in new hardware platforms. The more compatible existing system hardware and software are to the ERP package, the greater the chance of the company diffusing it extensively.

The positive relationship of RELADV2 and breadth of diffusion shows that companies are motivated to integrate ERP extensively into operations when they are aware of the important cost reductions that can be realized. The more an ERP application is diffused throughout company sites, the more evident employee reductions and IT cost savings. Companies will not waste scarce resources on an ERP if they do not think it will meet their needs. The more apparent an ERP's benefits to a company, the greater the chance of an extensive implementation.

An interesting finding is the negative relationship between RELADV1 and BREADTH. RELADV1 measures improved productivity in various aspects of the company such as inventory reductions, improved order management and cycle times, and cash management. Whereas the survey items comprising the scale for RELADV2 are general, the questions comprising the RELADV1 scale are more specific. Reduction in employees and IT costs may be more evident than productivity benefits, which must have certain metrics in place to track improvements. If a company does not establish a set of metrics to track improvements in functional areas, management will have no way to gauge the success of an ERP installation. Therefore, one possible explanation for the negative relationship between RELADV1 and BREADTH is that companies may not have had mechanisms in place to determine whether any of the productivity benefits had been realized.

Another reason why RELADV1 might be inversely related to BREADTH is that productivity improvements are not usually evident post "go-live." According to Deloitte Consulting (1999), it is not unusual for companies to see a "dip" in performance immediately after an ERP installation. This "dip" in performance could last several months while the company tries to stabilize after undergoing an intensive and arduous implementation. Consultants propose that productivity improvements from an ERP installation are not fully realized until companies build upon their ERP platform with add-on modules such as customer relationship management (CRM), supply-chain management (SCM), and e-business.

The relationship of time (ELAPSE) to relative advantage is highlighted in the correlation matrix (Table 8). While the relationship between RELADV1 and ELAPSE is significant, the relationship between RELADV2 and ELAPSE is not significant. This adds further evidence that time does play a role in the realization of productivity benefits to a company. Thus, while relative advantage has been operationalized in prior studies as one construct, the separation into two types of benefits provides richer information in the present study.

As expected, smaller organizations had more extensive breadth of diffusion. Smaller companies have fewer employees and fewer implementation sites, so it is easier for them to diffuse ERP components. Larger companies will have more problems with coordination and control when implementing a project as extensive as an ERP system. Furthermore, company locations for a larger firm tend to be more geographically dispersed than for a smaller company, which further complicates the implementation process.

Finally, the results show that competitive pressure is negatively associated with breadth of diffusion of ERP. This finding is contrary to the model's predictions. Competitive pressure was expected to be positively related to both dimensions of diffusion because it is often mentioned in the anecdotal literature as a reason why organizations adopt and implement an ERP (Jenson and Johnson, 1999; Laughlin, 1999). Furthermore, research has shown that in competitive industries there is a constant need for firms to adopt and implement technologies to gain competitive advantage (Premkumar et al. 1997). While the few studies that have included competitive pressure as a DOI environmental variable have shown either a positive association (Robertson and Gatignon, (1986) or no association (Thong, 1999), this is the first study that has shown a negative association. The result could be due to either a scale artifact or to the fact that this study examined an *intra*-organizational technological innovation while the few studies examining competitive pressure focused on *inter*-organizational innovations, such as EDI (Reekers and Smithson, 1994; Iacovou et al. 1995; Bensaou and Venkatraman, 1996). Research has shown that competitive pressure positively affects the diffusion of EDI because, in many instances, businesses are coerced by their trading partners to implement EDI.

Refusal to implement EDI can result in a loss of business-to-business commerce within a company's supply chain.

Perhaps the "push" to adopt ERP comes from the need to have an infrastructure in place on which to launch the "second wave" of ERP (Deloitte Consulting, 1999). According to Deloitte Consulting (1999), the "second wave" refers to actions that take place post-"go live" that help organizations achieve the full capabilities and benefits of an ERP-enabled process. These actions consist of leveraging the shared relationship database and client-server technology of an ERP to exploit specific strategic based applications, such as electronic commerce and flow (or lean) technology for manufacturing. While experts agree that an ERP initiative does occur in waves that must be properly managed, there is no consensus on which part of the ERP process is linked to competition and strategy. Future research is needed to analyze the stages of an ERP initiative further to discover the links to competition and strategy.

Depth of Diffusion

Depth of diffusion refers to how the technology is used in an adopting organization. For the purposes of this study, this measure consists of the number of different components (i.e., Financial (FI), Controlling (CO), or Plant Maintenance (PM)) that were adopted by a firm. Only one variable, SIZE, was found to be significant in the proposed model. While SIZE was negatively related to BREADTH of diffusion, its relationship to DEPTH is positive. Although larger firms may experience problems with coordinating an implementation of an enterprise wide system, they generally make greater use of innovations they adopt because they have more IS needs. Additionally, larger firms have more slack resources than smaller businesses and thus are able to fund an expensive systems implementation. Presently, companies spend one to two percent of their annual revenues on purchasing and implementing an ERP system (Mraz, 2000). These costs include hardware, software, training, and consultant assistance. For large companies, it is not unusual to see the training and implementation costs run several times the software costs (Mraz, 2000).

These results suggest that once large companies invest in these systems, they make greater use of the technology by adopting more of its components. Thus, separating extent of diffusion into its two dimensions, breadth and depth, has provided a richer analysis of the relationship of size to the implementation process of ERP.

Only one other variable, ELAPSE, was near significance at the 0.05 level. This would suggest that the longer a company is involved in the ERP installation, the more components they will implement. No other DOI variables were near significance, which raises questions about the ability of traditional DOI variables to explain the diffusion process of an enterprise-wide technological innovation. While DOI theory has served as the framework for many innovation diffusion studies, the current study is one of the first to apply the framework to an enterprise-wide technology. Because the implementation process is such a massive undertaking, in some cases taking years to complete, the effect of traditional DOI variables on the implementation process may be obscured. Additionally, one of the major reasons why organizations implemented ERP systems in the 1990s was that their systems were not Year 2000 compliant. The effect of non-compliance of systems on the diffusion of ERP systems might have further obscured the hypothesized relationships between the independent variables studied and the implementation process. Finally, in most cases, adoption of an enterprise-wide technological innovation is mandated by top management rather than left up to the discretion of individual employees. Top management mandate may further convolute the effect of these variables.

Implementation Success

For an ERP implementation to be successful, it must satisfy the needs of all the stakeholders of the system including top managers, functional managers, and users. Two innovation characteristics, RELADV1 and COMPLEX, and one organizational characteristic, TOPMGMT, were found to be significant in the model.

The more complex an innovation is perceived to be, the less system stakeholders are satisfied and the less willing they are to accept the technology. According to anecdotal literature, one of the main factors that can derail an ERP implementation is underestimating organizational resistance to change (Laughlin, 1999). One of the ways organizations can manage resistance is including users from various functional areas on the project team. These users can provide input into business process changes and software configuration within their departments. They can also be instrumental in effecting changes by communicating to their various departments the importance of the project. Additionally, they can be a key resource for training and a liaison between employees and management regarding any user concerns with the ERP and the implementation process. It is essential to prepare employees for what lies ahead in an ERP implementation. The proper management of perceptions regarding the complexity of an ERP can effect a more successful implementation.

It is interesting to note that COMPLEX has not been significant in either diffusion model. This lack of significance suggests that, regardless of the level of perceived complexity, once top management makes a commitment to invest in an ERP, a company will diffuse it as planned. These findings are contrary to McGowan and Madey's (1998) study, which found that complexity was related to breadth of diffusion of EDI. However, ERP and EDI are vastly different types of technological innovations. While ERP is an *intra*organizational innovation, EDI is an *inter*organizational innovation. Additionally, EDI affects only certain types of transactions (e.g., sales and purchases), while an ERP encompasses all organizational transactions and business processes. Therefore, it is not surprising to find that certain variables that explain the diffusion of EDI do not explain the diffusion of ERP.

As expected, TOPMGMT is also highly significant in the model. The strong support from top management has consistently been found to be important for successful IS implementations (Sanders and Courtney, 1985; Guimarnes et al. 1992). Without top management's vision and direction, stakeholders of the system will be less willing to accept the system. In the majority of cases, ERP implementations do not fail because the applications do not work. They fail because the enterprise rejects them (Laughlin, 1999). According to Laughlin

(1999), the first order of business in an ERP installation is to gain the full commitment from senior executives. They are the ones that must deal with organizational resistance. If an ERP implementation fails, it usually means that the leadership within the company has failed.

Also significant in the model is RELADV1, or the advantages of ERP in terms of productivity improvements. The greater the perceived productivity advantages, the higher the satisfaction of key stakeholders. It is interesting to note that RELADV2, employee and IT cost reductions, is not significant in the model along with RELADV1. A possible explanation for this result is that the measure of stakeholder satisfaction included satisfaction of users of the system. It is not surprising that user satisfaction would not increase with reductions in number of employees, as those persons are the ones affected by layoffs.

CHAPTER VII

CONTRIBUTIONS, LIMITATIONS AND FUTURE RESEARCH

This study examines the implementation process of ERP systems by drawing upon DOI theory and IS implementation literature. The objective of this study was to determine if there was a relationship between certain innovation, organizational, and environmental variables (compatibility, complexity, two measures of relative advantage, top management support, business process reengineering, centralization, formalization, organizational complexity, and competitive pressure) and extent of diffusion of ERP and implementation success.

The results indicate that compatibility, both measures of relative advantage, and competitive pressure are instrumental in explaining the breadth of diffusion of ERP. Additionally, size, a control variable was significant in the model. While none of the independent variables was significant in the depth of diffusion model, the control variable, size, was significant, but in the opposite direction as reported in the breadth of diffusion model. Complexity, one measure of relative advantage, and top management support were key factors related to implementation success.

This study contributes to DOI and IS literature in several ways. It is perhaps one of the first studies to examine the intra-organizational diffusion of ERP from both a theoretical and empirical perspective. Second, it contributes to the development of a unifying theory for IT diffusion, which at this time is lacking in the literature. Finally, this research focuses on the implementation process of an IT innovation, while the majority of DOI studies examine only the adoption stage.

The results also have implications for practitioners in that they provide some explanations of the contextual factors that influence the intra-organizational diffusion of ERP and implementation success. This is of current importance to practitioners faced with failed ERP implementations and schedule and cost overruns. The findings suggest that practitioners may have more influence over breadth rather than depth of diffusion of an ERP. One variable highly related to breadth of ERP diffusion is compatibility. While practitioners have little control over the compatibility of existing hardware and software with the ERP application, they can bring operating practices in line with changes to be introduced by an ERP. Change management requires extensive planning and blueprinting of the desired system and having a written business case that identifies key reasons for proceeding. Practitioners need to formally communicate these reasons to employees and help everyone understand their contribution to the process as well as implications their decisions have on the value of the organization. According to Brakely (1999), successful ERP deployments feature rigorous change management programs, the objectives and metrics of which are tied to the business model blueprint. Furthermore, power cannot remain in the hands of people with old values and behaviors. Practitioners should be cognizant of barriers that may stand in the way of a successful deployment of ERP. These barriers may be in the form of certain personnel in the organization that resist change or certain beliefs ingrained in the culture of the organization. Practitioners need to seek out leaders and become change advocates, not technology pushers. They need to seek political allies and lead change through example (Harty, 1998).

Practitioners also can assist in communicating to company personnel the relative benefits of an ERP over their current systems. Practitioners should educate organizations as to their true performance potential by pointing out improvements that can be realized from an ERP. Additionally, practitioners should strive to achieve early successes, which is one of the keys to a winning ERP implementation (Laughlin, 1999). Whether the early success is a speedier monthly closing time or reduced product-ordering time, it should be publicized and used to encourage and facilitate continued deployment of the technology.

Several limitations of this study should be recognized. To control for potential confounding issues, this study examines only SAP installations. Future research could either compare the results of this study with the diffusion of other ERP systems or compare companies' implementation experiences with each of the major ERP packages.

Second, the sample is limited to only manufacturing companies. Most DOI studies have focused primarily on not-for-profit and public sectors, while very few have tested DOI theory in the manufacturing environment. By sampling manufacturing firms, this research extends DOI theory to another setting. This extension is an added contribution of the paper; however, it may limit generalizability to other types of companies.

Another limitation is the sample size. Because of the length of the questionnaire and the difficulties inherent in obtaining data from high-level executives, the sample size was smaller than desired. However, the response rate of those contacted was very high (78 percent), and richer data was obtained due to in-depth interviews. Furthermore, responses can be compared with more confidence since all survey respondents were SAP project managers. This enhances the internal validity of the study. Future research can test the framework on a larger sample of organizations.

Another limitation of the sample should be noted. Survey respondents were randomly selected from a convenience sample so there is no way to test for nonresponse bias. Furthermore, the sample consisted of SAP project managers who might exhibit a bias toward reporting their firm's implementation success. However, since no company names were mentioned in the study, and the researcher prefaced the survey with assurance of respondent anonymity, the possibility of bias was minimized. Moreover, in many firms the project manager is the only person qualified to answer the survey questions. Future research can build upon the current study by surveying several organizational users within each firm to get different perspectives of the ERP implementation process and to check for inter-rater reliability.

Another limitation is that the sample only included firms that were in the process of diffusing ERP within their organizations. Firms that have attempted to implement an ERP but failed were not included in the sample. Future research should include firms that have failed in the implementation process to look for differences in the variables that could explain the success or failure of an ERP implementation.

Finally, the model proposed and tested was based on a set of variables identified in DOI theory. The model is by no means comprehensive or exhaustive. A complete model would include a set of unlimited variables, and thus obtaining enough data to test it would be impossible. Future research could explore other variables that may influence the diffusion and implementation success of ERP. Recent IT diffusion studies have suggested several variables that might affect the diffusion and implementation success of technological innovations: extent of employee training (Ramamurthy and Premkumar, 1995), organizational learning (Fichman and Kemerer, 1997), and pre-implementation planning (McGowan and Madey, 1998). Additionally a recent meta-analysis of IT innovation diffusion studies encourages the development of more sophisticated models through the synthesis of other research streams, such as knowledge barriers, increasing returns, and social bandwagons (Fichman, 1999).

Other variables more distinctive of the diffusion process of enterprise-wide systems should be identified. One such variable might be the role of external consultants. It would be interesting to examine the impact of using external consultants versus in-house staff has on the ERP implementation process. Another issue identified during in-depth interviews with project managers is the importance of the stability of the consulting team. Many survey respondents commented on the instability of the consulting team used during the implementation. The problem was especially marked with large consulting firms.

The constant replacement of consultants or the use of inexperienced consultants caused disruption in the ERP implementation process. The inexperience of outside consultants was a problem for many companies in the sample. This resulted from a "bait and switch" situation in which senior consultants secured an implementation contract and then sent junior consultants to the engagement. Technology analysts emphasize that a consulting contract should include the seniority level and even, if desired, exact names of those consultants an organization wishes to have on the engagement. By specifying in the contract agreed upon expertise levels, companies can expect a smoother implementation process guided by knowledgeable and capable consultants.

Future research also could examine the relationship of certain DOI variables on the timing of ERP adoption. Because the majority (60 percent) of the firms in this study adopted ERP between 1997-1999, testing this relationship was impossible due to the lack of variance. A larger sample comprising a greater span of time could lend itself to testing this dimension of DOI theory, which classifies firms into early or late adopters, attempting to find differences between them.

Another avenue for additional research could entail exploring, on a longitudinal basis, the impact of ERP on culture, structure, and internal work-practices. For example, studies could explore how an ERP has changed the production planning process or the financial management process. Studies could explore how the integration of business processes and improved visibility of information has changed the corporate culture or structure. One likely result of an

ERP application on the corporate structure would be to decentralize the company due to more information being in the hands of users. The corporate culture may also change due to increased system openness and interdepartmental communication.

The mixed findings in prior studies have prompted the idea that a unifying theory of IT diffusion will be lacking unless researchers position their studies around certain locus of impacts (Prescott and Conger, 1995). This is one of the first studies to use this classification scheme in an attempt to further IT diffusion research. However, this dissertation makes an additional contribution to literature by suggesting that enterprise-wide technologies should be classified separately from other intra-organizational technologies, which may have limited organizational scope (i.e., quick response technology). Research in this area is relatively unexplored and should be a focal point for future studies as many emerging technologies will have a similar presence in organizations (e.g., electronic commerce and data warehousing). The emerging technologies of the new millennium create additional questions regarding diffusion, and this dissertation is a starting point for our understanding of these complex technologies.

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Appendix

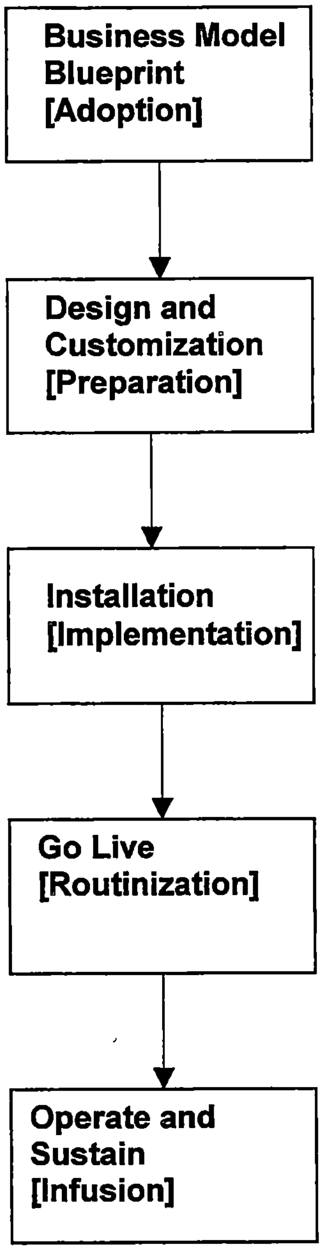

Figure1. ERP Implementation Process and Correspondence to a Model of Innovation Diffusion

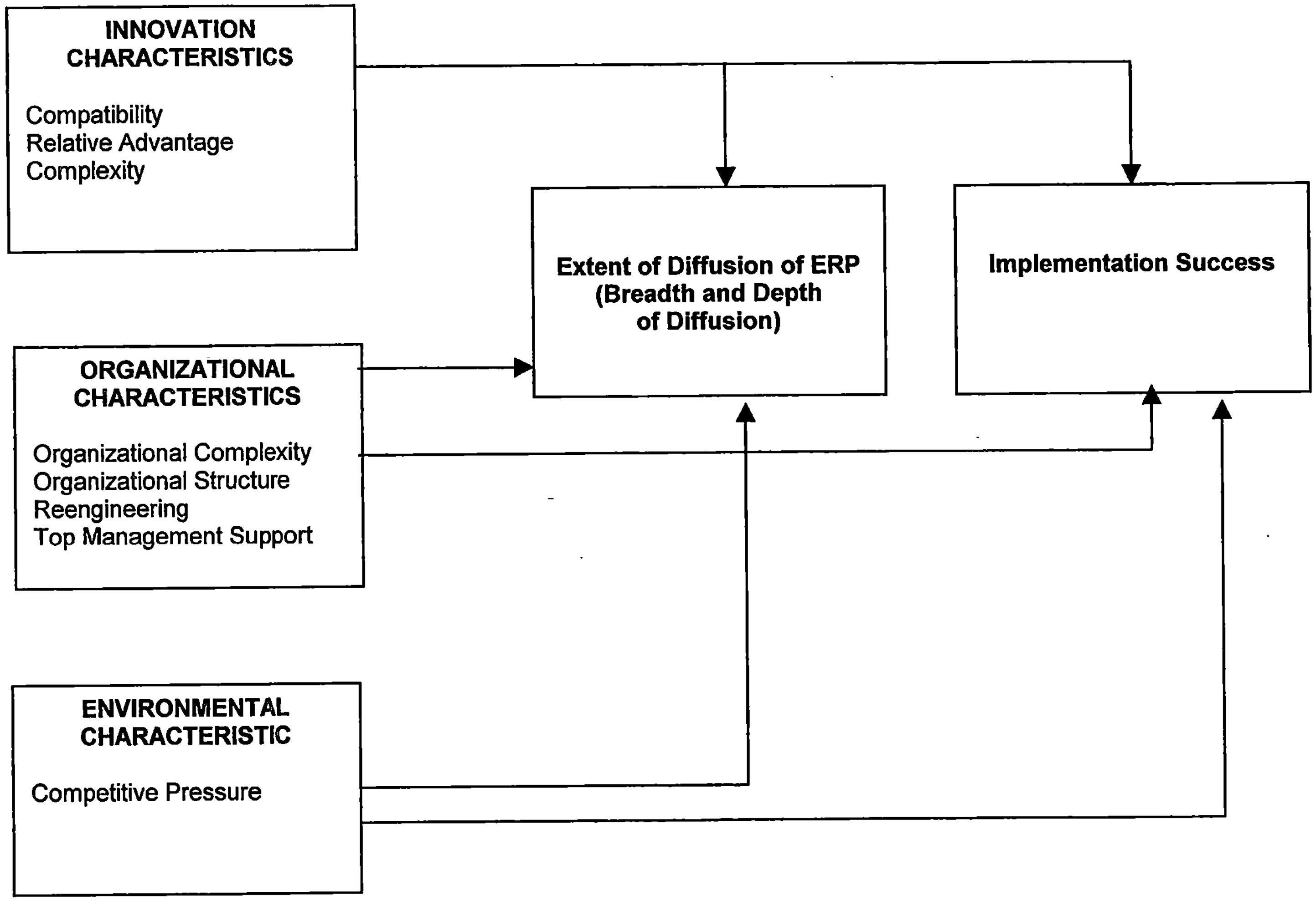

Figure 2. Model of ERP Diffusion

Table 1. Abbreviations	
ERP	Enterprise Resource Planning
IT	Information Technology
SAP	Systems, Applications, and Products in Data Processing
DOI	Diffusion of Innovation
IS	Information Systems
AI	Artificial Intelligence
CASE	Computer Aided Software Engineering
ISDN	Integrated Services Digital Network
EDI	Electronic Data Interchange
QR	Quick Response (Technology)
DDMS	Distributed Database Management System
PC	Personal Computer
IBM	International Business Machines
SBU	Strategic Business Unit
ASUG	America's SAP User Group

Table 2. Innovation Characteristics	
Innovation Characteristics	**Related Work**
Classic Innovation Characteristics: Relative Advantage, Compatibility, Complexity, Trialability, Observability	(Cooper and Zmud, 1990; Moore and Benbasat, 1991; Meyer and Goes, 1988; Tornatzky and Klein, 1982; Rogers, 1983; McGowan and Madey, 1998; Niederman, 1998; Ramamurthy and Premkumar. 1995; Kwon and Zmud, 1987).
Other Characteristics: Cost, Communicability, Divisibility, Profitability, Social Approval, Voluntariness, Image, Visibility, Result Demonstrability	(Moore and Benbasat, 1991; Tornatzky and Klein, 1982; Downs and Mohr, 1976; Niederman, 1998; Leonard-Barton, 1988)

Table 3. SAP System Components	
FINANCIALS	
Financial Accounting	Collects all data in company relevant to accounting.
Controlling	Provides a uniform reporting system for coordinating the contents and procedures of company's internal processes.
Investment Management	Offers integrated management and processing of investment measures and projects from planning to settlement including depreciation simulation.
Treasury Management	Monitors and analyzes cash holdings, financial deals, and investment risks.
Enterprise Controlling	Continuously monitors company's success factors and performance indicators.
HUMAN RESOURCES	
Personnel Management	Automates personnel management processes including recruitment, business travel and vacation time.
Payroll	Handles accounting and preparation of checks related to employee salaries, wages and bonuses.
Time Management	Provides a variety of standard reports that will assist in tracking and analyzing employee time.
Personnel Development	Assists in planning, monitoring, and analyzing scheduled seminars, training courses, and business events, registration and booking, price determination and invoicing.
Organizational Management	Complete solution for personnel cost planning.
MANUFACTURING AND LOGISTICS:	
Production Planning and Control	Performs capacity planning and creates a daily production schedule for a company's manufacturing plants.
Quality Management	Monitors, captures, and manages all processes relevant to quality assurance along the entire supply chain.
Materials Management	Optimizes all purchasing processes with workflow-driven processing functions, enables automated supplier evaluation, lowers procurement and warehousing costs, and integrates invoice verification.
Service Management	Provides highly integrated customer service functionality to compete in today's global markets.
Project System	Monitors costs and work schedules on a project-by-project basis.
Plant Maintenance	Sets plans and oversees upkeep of internal facilities.
Product Data Management	Supports in creating and managing product data throughout the product life cycle.
Sales and Distribution	Supports sales and distribution activities such as pricing, prompt order processing, on-time delivery, interactive variant configuration, and a direct interface to profitability analysis and production.

Table 4. Variable Abbreviations	
COMPAT	Compatibility
COMPLEX	Complexity
RELADV1	Relative Advantage in terms of reduced costs and employees
RELADV2	Relative Advantage in terms of improved productivity
PRESSURE	Competitive Pressure
TOPMGMT	Top Management Support
CENT	Centralization
FORM	Formalization
ORGCOMPLEX	Organizational Complexity
ELAPSE	Elapsed Time
SIZE	Size of Company
BPR	Business Process Reengineering
DEPTH	Depth of Diffusion
BREADTH	Breadth of Diffusion

Table 5. Variables Influencing ERP Diffusion and Implementation Success			
VARIABLE	**EXPECTED RELATIONSHIP TO DIFFUSION (Breadth and Depth)**	**EXPECTED RELATIONSHIP TO IMPLEMENTATION SUCCESS**	**REFERENCE**
Innovation Characteristics			
Compatibility	+	+	Rogers (1983); Tornatzky and Klein (1982); Fichman (1999).
Relative Advantage	+	+	Rogers (1983); Tornatzky and Klein (1982); Fichman (1999).
Complexity	-	-	Rogers (1983); Tornatzky and Klein (1982); Fichman (1999).
Organizational Characteristics			
Mechanistic Organizational Structure	+	+	Rogers (1983); Damanpour (1991); Zmud (1982); Gosselin (1997).
Organizational Complexity	-	-	Rogers (1983); Norris et al. (1999); Kimberly and Evanisko (1981); Meyer and Goes (1988); Palmer (1998).
Top Management Support	+	+	Sanders and Courtney (1985); Zmud (1984). Ramamurthy and Premkumar (1995).
Business Process Reengineering	+	+	Ramamurthy and Premkumar (1995)
Environmental Characteristic			
Competitive Pressure	+	No association	Thong (1999); Robertson and Gatignon (1986); Fichman (1999); Premkumar et al. (1997).

Table 6. Profile of Survey Respondents		
	Frequency	**Percentage**
Industry		
Electrical	7	14
Chemical	6	12
Metal	3	6
Food/Beverage	8	15
Consumer Products	7	14
Plastic	3	6
Paper	4	8
Oil	2	4
Electronics	5	10
Other	6	11
Experience with ERP		
Less than 2 years	14	27
2-3 years	17	33
4-5 years	13	26
6-7 years	4	8
More than 7 years	3	6
Company employees		
Less than 1,000	9	18
1,000-1,999	9	18
2,000-4,999	11	21
5,000-9,999	9	18
10,000-49,000	8	15
50,000 or more	5	10

Table 7. Validity and Reliability Analysis

Variables	Item	Factor Loading	Mean	Standard Deviation	Cronbach alpha	Eigen value	Variance Explained	Cumulative Variance
Complexity[a]	Complex1	.72	16.51	5.21	.88	4.70	29.37	29.37
	Complex2	.71						
	Complex3	.89						
	Complex4	.93						
Top Management Support[a]			21.18	4.78	.85	2.96	18.48	47.85
	Top1	.88						
	Top2	.81						
	Top3	.80						
	Top4	.81						
Compatibility[a]			9.98	4.66	.79	1.68	10.46	58.30
	Compat1	.78						
	Compat2	.80						
	Compat3	.70						
Competitive Pressure[a]			11.33	4.09	.64	1.50	9.39	67.69
	Pressure1	.79						
	Pressure2	.74						
	Pressure3	.67						
Business Process Reengineering[a]			7.69	3.06	.75	1.13	7.06	74.75
	BPR1	.93						
	BPR2	.71						
Relative Advantage[b]								
Relative Advantage-1 (Increased productivity)			23.05	6.53	.79	3.52	43.93	43.93
	RelAdv1	.82						
	RelAdv3	.65						
	RelAdv6	.88						
	RelAdv7	.53						
	RelAdv8	.70						
Relative Advantage-2 (Decreased costs)			11.04	4.39	.83	1.56	19.51	63.44
	RelAdv2	.73						
	RelAdv4	.86						
	RelAdv5	.93						
Organic/Mechanistic Organizational Structure[c]								
Centralization			15.63	5.29	.87	3.55	50.70	50.70
	Mgmt1	.83						
	Mgmt2	.78						

Table 7. Continued								
	Mgmt3	.93						
	Mgmt4	.77						
Formalization			11.55	3.36	.74	1.42	20.28	70.98
	Mgmt5	.74						
	Mgmt6	.86						
	Mgmt7	.77						

[a] These variables were subjected to factor analysis together. The variances and cumulative variances reported are the results of extraction into five separate factors.

[b] Split into two factors. RELADV1 measures increased productivity due to ERP and RELADV2 measures decreased costs.

[c] Split into two factors. CENT measures the degree of centralization in a firm and FORM measures the degree of formalization.

Table 8. Correlation Matrix

	COMPAT	COMPLEX	REL ADV1	REL ADV2	PRESSURE	TOP MGMT	CENT	FORM	ORG COMPLEX	ELAPSE	SIZE	BPR
COMPAT	1.000											
COMPLEX	-.469**	1.000										
RELADV1	.036	-.303*	1.000									
RELADV2	-.039	-.287*	.382**	1.000								
PRESSURE	.012	-.233	.162	.599**	1.000							
TOPMGMT	.131	-.278*	-.094	.327*	.250	1.000						
CENT	-.012	-.368**	-.012	-.080	.049	-.340*	1.000					
FORM	.105	-.172	-.059	-.317*	-.352*	-.134	.392**	1.000				
ORGCOMPLEX	-.112	-.080	.022	.000	-.004	.047	-.082	-.001	1.000			
ELAPSE	-.129	-.092	.321*	.130	-.038	029	-.136	-.095	.026	1.000		
SIZE	-.038	-.198	.409**	.134	.110	-.128	.145	.062	.577**	.244	1.000	
BPR	.098	-.177	.156	.180	.148	.229	-.118	-.236	.073	.105	.004	1.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

COMPAT=compatibility, COMPLEX=complexity, RELADV1= relative advantage in terms of increased productivity, RELADV2=relative advantage in terms of reduced costs and employees, PRESSURE=competitive pressure, TOPMGMT=top management support, CENT=centralization, FORM=formalization, ORGCOMPLEX=organizational complexity, ELAPSE=elapsed time, SIZE=company size, BPR=business process reengineering.

Table 9.
Binary Logit Results: High Breadth of Diffusion vs. Low Breadth of Diffusion

The table below reports the results of a binary logit test (1 = High breadth of diffusion and 0 = Low breadth of diffusion).

Factor	Parameter Estimate	Standard Error	Wald	P-value
Constant	21.507	10.237	4.414	.036**
COMPAT	2.712	1.255	4.670	.031**
RELADV1	-4.836	2.328	4.317	.038**
RELADV2	3.355	1.582	4.499	.034**
PRESSURE	-2.389	1.224	3.812	.050**
SIZE	-2.159	.977	4.881	.027**

Model fit: Chi-squared = 33.880 (df = 5, p < 0.0000)
Cox and Snell R Square = .579[a]
Nagelkerke R Square = .762[a]

Classification Table:

Observed	Predicted		Total	Percent Correct
	Low Breadth	High Breadth		
Low Breadth	15	2	17	88.2
High Breadth	4	19	23	82.6
Overall	19	21	40	85.0

** Indicates significance at the .05 level.
[a] Both Cox and Snell and Nagelkerke are analogous to the R^2 statistic used in multiple regression and both provide an indication of the logit model's explanatory power.

Table 10.
Binary Logit Results: Variables not in the Final Breadth of Diffusion Equation

The table reports the Wald score and significance of each of the remaining antecedent variables if added to the final equation in Table 7.

Factor	Wald	P-value
COMPLEX	.540	.462
CENT	2.152	.142
FORM	.072	.788
LOGSITES	1.705	.192
TOPMGMT	.042	.838
ELAPSE	.606	.436
BPR	.033	.856

Table 11. Binary Logit Results: High Depth of Diffusion vs. Low Depth of Diffusion				
The table below reports the results of a binary logit test (1=High depth of diffusion and 0=Low depth of diffusion).				
Factor	**Parameter Estimate**	**Standard Error**	**Wald**	**P-value**
Constant	-5.522	2.125	6.753	.009*
SIZE	.684	.259	6.983	.008*
Model fit: Chi-squared = 13.303 (df = 1, $p < 0.001$) Cox and Snell R Square = .283[a] Nagelkerke R Square = .378[a] Classification Table:				
Observed	**Predicted**		**Total**	**Percent Correct**
	Low Depth	**High Depth**		
Low Depth	13	6	19	68.4
High Depth	7	14	21	66.7
Overall	20	20	40	67.5

* Indicates significance at the .01 level.

[a] Both Cox and Snell and Nagelkerke are analogous to the R^2 statistic used in multiple regression and both provide an indication of the logit model's explanatory power.

Table 12. Binary Logit Results: Variables not in the Final Depth of Diffusion Equation		
The table reports the Wald score and significance of each of the remaining antecedent variables if added to the final equation in Table 9.		
Factor	**Wald**	**P-value**
COMPLEX	.009	.926
CENT	.204	.652
FORM	1.700	.192
PRESSURE	1.032	.310
TOPMGMT	.002	.968
RELADV1	.010	.920
RELADV2	.051	.821
ORGCOMPLEX	.106	.745
COMPAT	.865	.352
ELAPSE	3.423	.064
BPR	.976	.323

Table 13. Stepwise Linear Regression Results: Implementation Success						
Multiple R	.786					
R Square	.618					
Adjusted R Square	.588					
Standard Error	.775					
	DF	**Sum of Squares**	**Mean Square**	***F***	**Significance of *F***	
Regression	3	36.890	12.297	20.501	.000	
Residual	38	22.793	.600			
Model						
Variable	**B**	**Standard Error Of B**	**Beta**	***t***	**Significance of *t***	**Variance Inflation Factor**
Constant	3.109	.984		3.161	.003	
COMPLEX	-.440	.100	-.480	-4.399	.000**	1.184
RELADV1	.257	.094	.296	2.737	.009**	1.141
TOPMGMT	.427	.109	.421	3.932	.000**	1.161

** Indicates significance at the .01 level.

Table 14. Stepwise Linear Regression Results for Implementation Success: Excluded Variables		
Factor	**Beta In**	**P-Value**
COMPAT	-.174	.191
RELADV2	-.041	.743
FORM	-.052	.625
PRESSURE	-.076	.473
ORGCOMPLEX	.011	.914
SIZE	.016	.886
ELAPSE	-.075	.487
CENT	.216	.052
BPR	.024	.822

Table 15.
Results of Binomial and Linear Regression Models for Diffusion and Implementation Success

Variables	Breadth of Diffusion Hypothesis		Depth of Diffusion Hypothesis		Implementation Success Hypothesis	
	No.	Support	No.	Support	No.	Support
Compatibility	H1a	Yes	H1b	No	H1c	No
Relative Advantage1	H2a	No	H2b	No	H2c	Yes
Relative Advantage2	H2a	Yes	H2b	No	H2c	No
Complexity	H3a	No	H3b	No	H3c	Yes
Centralization	H4a	No	H4b	No	H4c	No
Formalization	H4a	No	H4b	No	H4c	No
Organizational Complexity	H5a	No	H5b	No	H5c	No
Top Management Support	H6a	No	H6b	No	H6c	Yes
Business Process Reengineering	H7a	No	H7b	No	H7c	No
Competitive Pressure	H8a	No	H8b	No	H8c	Yes
Size	Control	Significant	Control	Significant	Control	Not Sig.
Elapsed Time	Control	Not Sig.	Control	Not Sig.	Control	Not Sig.

QUESTIONNAIRE

SAP Survey. Administered by Marianne Bradford, Ph.D. Candidate, University of Tennessee College of Business Administration. All information will be kept confidential and analyzed in aggregate. A benchmarking study will be available upon request. Thank you for your assistance.
What does your company manufacture? ____________________

Directions: Read the sentences below. The answers range from 1 (strongly disagree/false) to 7 (strongly agree/very true). Decide how much you agree or disagree with the statement as it applies to the SAP implementation for your specific business unit.

1 = if you strongly disagree with the statement
2 = if you moderately disagree with the statement
3 = if you slightly disagree with the statement
4 = if you are neutral, you cannot decide
5 = if you slightly agree with the statement
6 = if you moderately agree with the statement
7 = if you strongly agree with the statement

Compatibility

1. The ERP application was compatible with legacy system software that was retained (minimal interfacing).

2. The ERP application was compatible with hardware that was retained.

3. Our firm's existing operating practices were compatible with changes to be introduced by ERP.

Complexity

4. Our firm's interaction with the ERP system is clear and understandable.

5. It is easy for firm employees to get the ERP system to do what they want it to do.

6. Learning to use the ERP system has been easy for employees.

7. Overall, the ERP system is easy to use.

Competitive Pressure

8. Our firm experienced competitive pressure to implement an ERP.

9. Our firm had poor/uncompetitive business performance, which led to adoption of ERP.

10. Our firm would have experienced a competitive disadvantage if ERP had not been adopted.

Top Management Support

11. SAP receives strong active support from top management.

12. Upper management has provided adequate financial and other resources to the SAP implementation effort.

13. SAP has been closely tied to the competitive strategies of the firm.

14. The success of SAP implementation efforts was due to the active championing by key senior management person(s).

Business Process Reengineering

15. Our firm spent much time in redesigning business processes before configuring software.

16. Our firm tried to fit the ERP package to our business processes with a minimal amount of business process reengineering. (reverse)

Implementation Success

17. Users are satisfied with the ERP package.

18. Top management of our firm is satisfied with the ERP package.

19. Functional managers are satisfied with the ERP package.

Relative Advantage

1. The ERP enables our firm to reduce inventory levels.

2. The ERP enables our firm to reduce the number of employees.

3. The ERP leads to great productivity improvements at our firm.

4. The ERP facilitates IT cost reductions at our firm.

5. The ERP leads to reductions in IT staff.

6. The ERP improves order management and cycle times at our firm.

7. The ERP improves cash management at our firm.

8. The ERP cuts costs in procurement at our firm.

Size

How many employees are in your company? (If you are the project manager for a strategic business unit (SBU) please indicate the number of employees within the SBU) ______________

Adoption Timing

	MONTH	YEAR
When did your company adopt ERP?	______	______
When did implementation begin?	______	______

Mechanistic/Organic Structure

The following items pertain to the management philosophy that actually gets used in your organization, not the philosophy that is preferred. Please circle the appropriate number. A "1" represents the expression on the left-hand side and a "7" represents the expression on the right-hand side, with "4" as the mid-point standing for a combination of the two ("some of both"). Your organization's operating management philosophy exhibits:

1. Highly structured channels of communication and highly restricted access to important financial and operating information	1	2	3	4 some of both	5	6	7	Open channels of communication with important financial and operating information flowing quite freely throughout the organization
2. Strong insistence on conforming to accepted standards and specifications	1	2	3	4 some of both	5	6	7	Strong support for challenging accepted standards and specifications
3. Strong emphasis on avoiding or minimizing risky activities	1	2	3	4 some of both	5	6	7	Strong encouragement to look for new and novel opportunities
4. A strong emphasis on holding fast to true and tried management principles despite any changes in business conditions	1	2	3	4 some of both	5	6	7	A strong emphasis on adapting freely to changing circumstances without too much concern for past practice
5. Strong emphasis on always getting personnel to follow the formally laid down procedures	1	2	3	4 some of both	5	6	7	Strong emphasis on getting things done even if this means disregarding formal procedures
6. Tight formal control of most operations by means of sophisticated control and information systems	1	2	3	4 some of both	5	6	7	Loose, informal control; heavy dependence on informal relationships and norm of cooperation for getting work done
7. Strong emphasis on getting line and staff personnel to adhere closely to formal job descriptions	1	2	3	4 some of both	5	6	7	Strong tendency to let requirements of the situation and the individual's personality define proper on-job behavior

Organizational Complexity

How many sites are involved in the SAP implementation? ______________________

Extent of Diffusion

This section is intended to determine how extensive is the use of SAP within your company.

The Financial module of SAP includes financial accounting, controlling, investment management, treasury management, and enterprise controlling. What percent of company sites have **gone live** with the following Financial management components? **NA means Not Adopted; FP means Future Plans.**

FI: Financial Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

CO: Controlling
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

IM: Investment Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

TR: Treasury Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

EC: Enterprise Controlling
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

The Human Resource module of SAP includes personnel management, payroll, time management, personnel development and organizational management. What percent of company sites have **gone live** with the following Human Resources components? **NA means Not Adopted; FP means Future Plans.**

PM: Personnel Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

PA: Payroll Accounting
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

TM: Time Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

PD: Personnel Development
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

OM: Organizational Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

The Logistics and Manufacturing module of SAP includes production planning and control, quality management, materials management, service management, project system, plant maintenance, product data management, and sales and distribution management. What percent of company sites have **gone live** with the following Logistics and Manufacturing components? **NA means Not Adopted; FP means Future Plans.**

PP: Production Planning
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

QM: Quality Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

MM: Materials Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

SM: Service Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

PS: Project System
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

PM: Plant Maintenance
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

PDM: Product Data Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

SD: Sales and Distribution
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

OTHER MODULES

APO: Advanced Planner and Optimizer
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

BW: Business Warehouse
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

HSE: Health Safety and Environmental
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

InfoDB: Information Database
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

SEM: Strategic Enterprise Management
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

WF: Workflow

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

SALES: Sales Force Automation

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

ITS: Internet Transaction Server

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% NA FP

Vita

Marianne Bradford received her Ph.D. in Accounting from the University of Tennessee in 2000, with a minor in Statistics and a concentration in Information Systems. Her research interests include the impact of information technology on organizations, the adoption and diffusion processes of information technologies, and the use of information technology in lean (pull) manufacturing environments.

Marianne received a Master of Business Administration from Millsaps College in 1992 and a Bachelor of Accounting from the University of Mississippi in 1986. She is a Certified Public Accountant and has practitioner experience as an auditor and tax accountant for KPMG Peat Marwick. She also has worked in private industry as an Assistant Controller. Before entering the academe, Marianne taught accounting information systems and financial accounting at the University of Mississippi. She is currently employed at Bryant College in Smithfield, Rhode Island as an Assistant Professor in Accounting Information Systems. She is a member of the American Institute of Certified Public Accountants and the American Accounting Association, and is also an accounting textbook and supplements author and editor for John Wiley and Sons.