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The mediating role of organizational learning between absorptive capacity and performance in companies employing enterprise resource planning software

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THE MEDIATING ROLE OF ORGANIZATIONAL LEARNING BETWEEN ABSORPTIVE CAPACITY AND PERFORMANCE IN COMPANIES EMPLOYING ENTERPRISE RESOURCE PLANNING SOFTWARE

Dissertation

by

EDITH GALY

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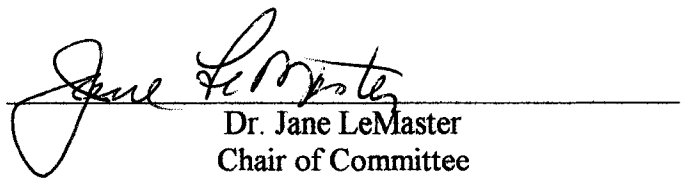

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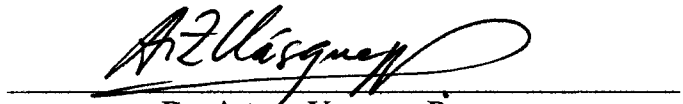

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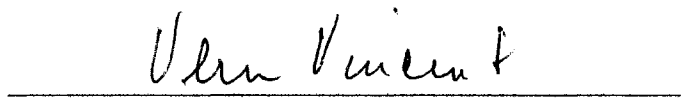

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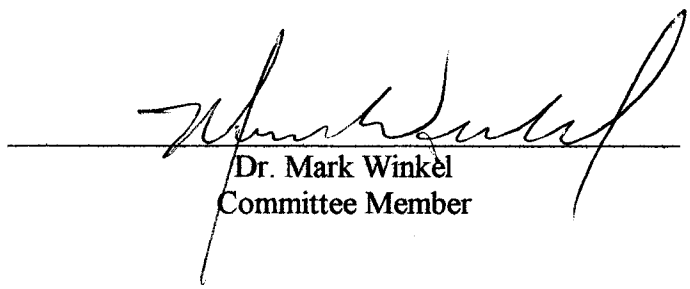

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ABSTRACT

Galy, Edith A., The Mediating Role of Organizational Learning between Absorptive Capacity and Performance in Companies Employing Enterprise Resource Planning Software. Doctorate of Philosophy (PhD) in Business Administration in International Business, December, 2003, 110 pp., 26 tables, 16 figures, references, 117 titles.

This dissertation focuses on the acquisition of information systems technology and how the acquisition of information systems (IS) can improve the performance of a firm. The central purpose of this dissertation is to contribute to the literature that explains the success of IS projects. It addresses the organizational processes that contribute to the successful implementation of IS, and explains why some organizations achieve financial returns and strategic advantages from their IS efforts while others do not.

The population in this dissertation consists of top level IS executives in the US or Canada employed in firms who have implemented enterprise resource planning software. Enterprise resource planning (ERP) has the capability to join disparate data sources and make them available across enterprises in an organized, personalized, secure, and searchable fashion. ERP integrates key business and management processes to provide a comprehensive view of an organization.

The term used in the literature to refer to firm readiness to technological advances is absorptive capacity. Absorptive capacity is an organizational, firm-level construct that incorporates a learning curve into the technology adoption process. Cohen and Levinthal (1990) define absorptive capacity as the firm's ability to perceive value in external

information, in this case an information system, and be able to adopt it, internalize it and exploit it to maximize profits. This dissertation tests the relationship between absorptive capacity and performance mediated by organizational learning. Absorptive capacity, therefore, is a measure of *potential* increase in performance but not a guarantee of increased performance. Several processes have to occur in order for organizations to learn. First of all, organizations have to acquire knowledge by eliciting or sharing knowledge (Argote, 1999) in the assimilation stage (Lane et al., 2001; Lane & Lubatkin, 1998). This stage is followed by a second stage named internalization or integration (Kim, 1998; Lyles & Salk, 1996). Group learning involves the processes through which members share, generate, evaluate and combine knowledge (Argote, 1999). The third stage, optimization, is where an organization reaches the point of exploitation of a *learned* technology (Cohen & Levinthal 1990, 1994).

The relationships between absorptive capacity, organizational learning and performance represent the research framework for the dissertation. A path begins from absorptive capacity to organizational learning, but because organizational learning is divided into three stages there are three separate paths leading to each level in organizational learning: assimilation, integration and optimization. Structural equation modeling was used to examine the series of dependence relationships simultaneously.

DEDICATION

I dedicate this dissertation to my children: Guy Daniel, Stephanie Lucette and Eric Jean-Paul, so that they understand the value of perseverance, pride and accomplishment. To them I owe my strength and my purpose. What I say to them is simple:

Live, run, shine
Remain forever faithful, forever good and forever strong.

ACKNOWLEDGEMENTS

I would especially like to thank my family, my dear husband, my children, my mom, for their enormous support in this process, for their unconditional love, innumerable sacrifices, and unwavering belief in me. I would also like to thank my friends who went beyond the call of duty with their support and time and helping hands. Together all things are possible.

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CHAPTER I

INTRODUCTION

Absorptive Capacity and Performance

This dissertation focuses on the acquisition of information systems (IS) and how absorptive capacity and organizational learning can improve the performance of the firm. The extent to which IS is applied to critical organizational processes translate to truly significant gains effectiveness or efficiency varies within organizations (Boyton et al., 1994). The central purpose of this dissertation is to contribute to the literature that explains the success of IS projects. What organizational processes contribute to the successful implementation of IS? Why do some organizations achieve financial returns and strategic advantages from their IS efforts while others do not?

As corporations enter into international arenas as a result of globalization, there is a greater need for international information systems to transcend national barriers and become effective tools in providing inter-organizational efficiency and effectiveness. The majority of cross-cultural IS research has used the nation-state as a primary unit of analysis (Ein-dor et al., 1997; Keil et al., 2000; Montealegre, 1999;Watson et al., 1997).

This dissertation surveys firms in the United States and in Canada to compare and analyze differences in the technology adoption process within the two countries. Canada has a close relationship with the US, not only as a neighbor but also as a trade partner

enjoying preferential treatment through trade agreements such as North American Free Trade Agreement. Both Canadian and US companies have advanced IS applications and companies within both counties have sought to exploit technology at comparable rate than the US. This dissertation examines differences in IS absorptive capacity within the nation states of Canada and the United States.

"IS organizations will be called upon to deliver high impact business applications that facilitate strategic differentiation of their firm relative to its rivals in intensely competitive, fast-paced environments, (Clark et al., 1997 p. 446). The effectiveness of an organization to implement IS will depend on their ability to quickly acquire, renew and deploy superior IS knowledge and skills (Clark et al., 1997). The term used in the literature to refer to firm readiness to technological advances is absorptive capacity. Absorptive capacity is the firm's ability to perceive value in external information, in this case an information system, and be able to adopt it, internalize it and exploit it to maximize profits (Cohen & Levinthal, 1990).

The construct of absorptive capacity, introduced by Cohen & Levinthal (1990), has received increased attention in the IS literature for the past decade. Absorptive capacity is an organizational, firm-level construct that incorporates a learning curve into the technology adoption process. First of all, the construct is important because it recognizes that individual technological expertise within an organization is necessary but insufficient to increase a firm's performance measures. Technology adoption is only the first step in organizational learning, which can lead to internalization and finally optimization of the technology. It is in this final stage that performance measures are expected to improve. It is critical not to categorize a system a failure, when only in the

beginning stages of the learning process. What is essential is to measure and improve the factors composing absorptive capacity, so that the firm can reach the final stage of optimization of a technology. The construct of absorptive capacity is the culmination of a steady progression in IS research.

The literature indicates that the relationship between performance and absorptive capacity is positive, and therefore an improvement in absorptive capacity will increase the productivity or performance of the firm (Cohen & Levinthal, 1990, 1994;; Kim, 1998; Lane et al., 2001; Szulanski, 1996). The gap in the literature lies in the fact that few studies incorporate the idea that absorptive capacity conveys only a potential for success in technology adoption and not a direct assurance of increased performance. Though this has been observed by several authors including Zahra (2000), the evidence to support this view is limited.

Mediating Role of Organizational Learning

Mediating Role

This dissertation, however, proposes that the relationship between absorptive capacity and performance is mediated by organizational learning. Absorptive capacity, therefore, a measure of potential increase in performance but not a guarantee of increased performance. Employees in an organization must first learn the new technology (Lane & Lubantkin, 1998). Cohen and Levinthal (1990) call attention to the following "An organization's absorptive capacity does not simply depend on the organization's direct interface with the external environment. It also depends on the transfers of knowledge across and within subunits" (Cohen & Levinthal, 1990, p.997).

Organizational learning capability is the capacity to assimilate knowledge as in imitation, whereas problem-solving skills, another aspect of learning, represent the capacity to create new knowledge as in innovation (Kim, 1998). Because organizations learn at different paces, some organizations show productivity gains with experience while others evidence little learning (Argote, 1999). The literature points to three main categories of factors for explaining these differences in learning rates: increased proficiency of individuals, improvements in organizational technology, and improvements in structure (Argote, 1999). This study analyzes in depth the mediating role of organizational learning between absorptive capacity and performance.

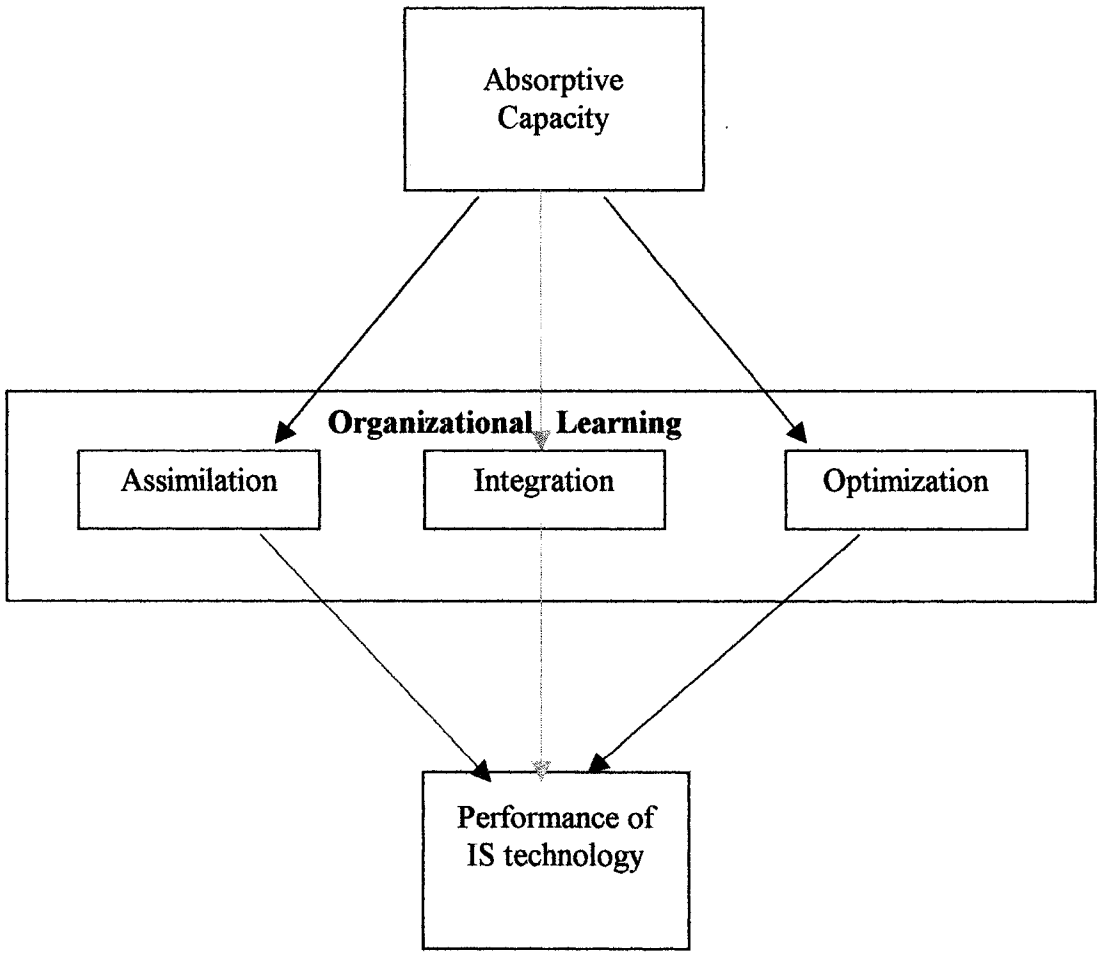
Stages in Organizational Learning

Several processes have to occur in order for organizations to learn. Organizations have to acquire knowledge by eliciting or sharing knowledge (Argote, 1999) in the assimilation stage (Lane & Lubatkin, 1998; Lane et al., 2001). This stage is followed by a second stage named internalization or integration (Kim, 1998; Lyles & Salk, 1996). Group learning involves the processes through which members share, generate, evaluate and combine knowledge (Argote, 1999). The third stage, optimization, is where an organization reaches the point of exploitation of a *learned* technology (Cohen & Levinthal 1990, 1994). "In order for a company to qualify as a knowledge creating company, it must have the organizational capability to acquire, accumulate, exploit and create new knowledge continuously and dynamically, and to recategorize and recontextualize it strategically for use by others in the organization" (Nonaka & Takeuchi, 1995, p. 233). At each stage of organizational learning the performance of the organization is measured and compared.

Most organizations seem to reach the first stage of organizational learning, which deals with assimilation or adoption of technology. Much of the existing technology adoption literature has been dedicated to measuring the variables and constructs involved in the decision to adopt a technology. Yet, there is little research showing what happens after the decision to adopt a technology is made and what variables and constructs are involved in adopting the technology to the higher levels of integration and optimization of a technology. Moreover, while the Technology Adoption Model, prevalent in information systems literature and explained in further detail in Chapter II, is used to predict an individual's adoption of a technology, absorptive capacity goes further into the internalization and optimization of the technology. A technology is adopted because the firm is expecting to improve the performance of the firm, and in order to exploit a technology, organizational learning must take place (Argote, 1999).

This dissertation assesses firms at all levels of organizational learning in order to provide a better explanation of why some firms achieve the optimization stage faster and others lag behind and reaching only the previous stages. In essence, the conceptual model for this dissertation, shown in Figure 1, proposes that the relationship between absorptive capacity and performance is indirect and therefore, there is a path from absorptive capacity to organizational learning, and from organizational learning to the performance of the firm. Consequently, the purpose of this dissertation is to study the relationship between absorptive capacity and performance of the firm, mediated by the stages in organizational learning. Organizational learning becomes an intermediary construct between absorptive capacity and performance. The stages in organizational learning studied in this dissertation are assimilation, integration and optimization.

FIGURE 1. Conceptual Model



Subsequent chapters of this dissertation are organized as follows: Chapter II reviews the literature with regards to the building of a Theory of Absorptive Capacity, integrating information systems literature with organizational learning literature. Also presented in Chapter II is the research model and hypotheses for the dissertation. Chapter III describes the research methodology section explaining the research design, measures, and the statistical tests that were used. The results and analyses of the findings of the research will be presented in Chapter IV, and the conclusions from the research are presented in Chapter V.

CHAPTER II

LITERATURE REVIEW

This chapter reviews the literature on the subject of absorptive capacity. The chapter begins by presenting a brief history of the information systems literature to show how the literature has progressed towards the development of this construct. The chapter continues with a definition and an introduction to absorptive capacity, followed by a description of the characteristics that compose the construct. These characteristics are listed as follows: a firm's level of prior related knowledge, diversity in background of employees, research and development (R&D), transfer of knowledge between departments, balance between internal and external communication patterns, commonality of knowledge between members within and among departments, organizational structure, a firm's compensation policies, and breadth of knowledge. Subsequently, there is an explanation of how the construct has evolved, and how organizational learning is an integral part of absorptive capacity. The next section discusses information systems performance measures with respect to the performance of the firm. The review of the literature ends with the conceptual model and the research hypotheses for the dissertation.

Absorptive Capacity

Development of Information Systems Leading to Absorptive Capacity

Just as a firm is an organization of people who have a common goal and vision, an information system is an organization of data often used to provide timely and accurate information for the decisions being made by people with a common vision. An information system contains all the components that work together to process and produce information. As a discipline, the information systems field is dedicated to the study of how information systems can succeed in providing decision-making information that will improve the performance of the firm.

The field of study known as information systems followed the widespread dissemination of computers, which escalated after the introduction of the personal computer in 1981. Before the advent of the personal computer, management of information systems was centralized in one department composed of very technical personnel who received requests from different functions of business. The first computer introduced in private businesses was the UNIVAC 1, in 1951. This means that for its 30-year history, up until the 1980s, information systems grew and evolved out of requests from non-IS managers rather than being immersed in the actual business process itself. The communication gap between the programmers who wrote the information systems, and the users who actually interacted continuously with the system, was wide. Nevertheless, the promise of a system that would reduce costs, increase efficiency, bring accurate and timely information enticed many to undertake projects directly.

Scholars have had ample examples of both successes and failures of firms that implement IS projects, and as a consequence address central issues to the successful implementation of IS projects that have emerged from the literature. These issues are 1) the user, 2) the impact on the organization, and 3) alignment of IS with the business strategy.

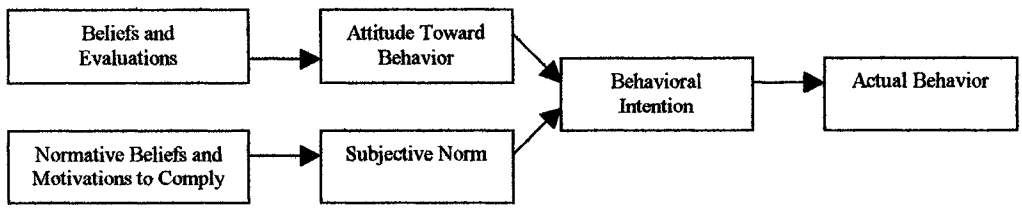
The User

Since the early 1970s, the scholarship in the field of IS has pointed to the user as the focal point for a systems success with the introduction of user involvement and user satisfaction as important explanatory variables. The fact that there was not enough user involvement in developing a system and consequently too little ownership of these systems led to a lack of use and dissatisfaction with information systems projects (Lucas, 1972,1974, 1978; Guthrie, 1974). User participation in the development of information systems (IS), however, is still encouraged because of its positive effects on the behaviors of IS users and the quality of IS. The model of user participation and involvement proposed by Hartwick and Barki (1994) includes concepts from procedural justice and self-efficacy research. Participation is manipulated at three increasing levels: (1) no voice, (2) non-instrumental voice, and (3) instrumental voice. Research findings indicate that users' *a priori* self-efficacy beliefs regarding their perceived ability to effectively contribute to the development process are positively related to desired participation, and that user participation can be effective, particularly when users perceive a noticeable degree of instrumental control over the decision outcome (Hartwick & Barki, 1994).

Fishbein and Ajzen (1975) developed the Theory of Reasoned Action Model (TRA) presented in Figure 2. TRA states that a behavior is determined by the person's

attitude and subjective norm concerning the behavior. Behavioral intention is composed of a person's intention to perform a specified behavior and the subjective norm perceived to be exerted on a person. A person's attitude is the product of a person's beliefs about the consequences of performing the behavior multiplied by the evaluation of those consequences. An individual's subjective norm, similarly, is the product of normative beliefs or perceived expectations multiplied by the motivation to comply with these expectations. The TRA model does not identify the specific beliefs to be used in the model noting that these must be developed from open-ended interviews. Factors not included in the model that might influence behavior are considered external variables.

FIGURE 2. Theory of Reasoned Action (TRA)

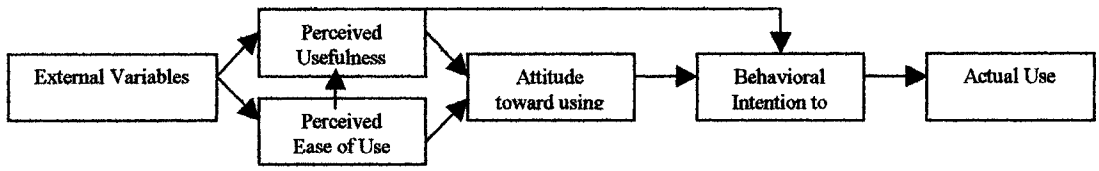


Fishbein & Ajzen, 1975

Davis (1986) developed the Technology Acceptance Model (TAM) shown in Figure 3, as a modified version of the TRA model specifically for the Information Systems field. The purpose of TAM is to explain computer acceptance in general terms. TAM measures the impact of external variables on internal beliefs, attitudes, and intentions. Perceived usefulness and perceived ease of use are the two main constructs in the model. Perceived usefulness refers to a person's perception of how the adoption of a new technology will increase the efficiency of the person's performance, and perceived

ease of use is the person's perception of how easy the technology will be to use. The less perceived effort the easier the technology will be to adopt. The TAM model does not include the subjective norm construct included in the TRA model, because it is not clear how to distinguish the subjective norm from the attitude toward behavior variable (Davis et al., 1989).

FIGURE 3. Technology Acceptance Model (TAM)



Davis, 1986

The proliferation of the personal computer was possible because of the applications written for it. The creation of new applications has created fertile ground to test the TAM model for how a user would decide to adopt applications. The recent explosion of the Internet has added a new dimension of information systems with global communication potential for every business. This again has given rise to research using the TAM model for applications ranging from e-mail and Lotus-Notes to other more integrative software such as Enterprise Recourse Planning (ERP). User involvement has continued to be a much-researched variable in today's literature. In 1990, AT&T's Quality Steering Committee suggested the IS function is in the business of serving customers which requires a thorough understanding of user expectations. In 1994, Le Plante and Alter addressed the need to use measures that embody senior level manager's definitions of value and to make continual surveys of end users an integral part of the way the IS function is managed. The user, therefore, whether as the customer, the

manager, or a staff employee continues to be the subject of academic study (Seddon et al., 1999;Wixom & Watson, 2001).

Organizational Impact

One user's perception and knowledge does not adequately measure that of the organization because organizational knowledge is not the sum of its member's individual knowledge. Organizational learning involves the transference of knowledge among its members. Knowledge travels formally through procedures and policies and informally through the organization's culture, and although an organization is composed of individuals, individuals in an organization cannot act alone. The impact of IS on the organization has been identified as an important variable in the IS literature (Callon, 1996; DeLone & McLean, 1992).

Kogut and Zander (1996) state, "Firms are organizations that represent social knowledge of coordination and learning"(Kogut & Zander, 1996, p. 502). Firms embody know-how and competence of individuals who interact to generate the capabilities of the firm. Coordination of individual competencies is developed within the organizational context of shared identities. And finally, this shared identity establishes explicit and tacit rules of coordination that influences the direction of organizational learning (Kogut & Zander, 1996). Spender (1996) notes "Organizations must be defined as systems of purposive activity"(Spender, 1996, p. 64). This purposive activity is held in the firm's leaders as a vision or mission driving the firm (Spender, 1996).

Alignment with Business Strategy

In the 1980s the notion that information systems could create strategic benefits leading to competitive advantage for the organization was conceptualized and

popularized. As early as the late 70s authors stressed that the IS function should be aligned with the strategic direction of the company (McLean & Soden, 1977). Parsons (1983) asserted that a firm could consider IS as an avenue to implement its existing competitive strategy, to affect its key competitive forces such as buyers, suppliers and rivals, as well as to change products, markets, or production economics of an entire industry. The literature has concluded that the most important point is to align effectiveness with corporate objectives, which may include exploiting market opportunities or fighting off the technological initiatives of competitors (Das et al., 1991; McFarlan, 1984; Segars et al., 1998).

Strategic business planning involves the integration of business objectives into functional areas, including information systems. The literature in strategic information systems confirms that it is not possible to formulate information systems strategy separate and independent of corporate strategy (Ives et al, 1993; Karimi & Konsynski, 1991). Byrd et al. (1995) concur stating that an information technology (IT) plan with an integrated business and technology focus results in better organizational performance than one without such integration (Byrd et al., 1995). The ability of a firm to coordinate management information systems planning with competitive strategy enables the firm to act upon market opportunities, gain competitive position, optimize the use of resources, and access pertinent decision-making information (Das et al., 1991). An objective of IS strategy is to delineate a desired distinctive competence for management information systems that supports and enhances corporate organizational strategy and capabilities. (Das et al., 1991).

While analyzing strategic information systems planning (SISP) and its relationship to the success of IS projects, much of the IS literature assumes that planning is a good thing and that a positive relationship exists between the success of the organization and planning. It is logical, therefore, to follow the planning process to the next step of its implementation. Planned implementation revolves around following a set of objectives and procedures as the modules of an umbrella IT strategic plan begin to be implemented. However, what happens is change and emergent technologies demand attention, and cause previous plans to come to an abrupt halt. Recognizing the dynamic nature of the relationships between the environment and strategic MIS planning calls for continuous monitoring and revising of the same strategy (Das et al., 1991). Previous research has indicated that SISP encounters many obstacles as they carry out the planning process (Lederer & Sethi, 1992). Failure in SISP effectiveness can cause lost opportunities and wasted information system resources and the high costs associated with SISP are a powerful deterrent to SISP type systems (Byrd et al., 1995; Earl, 1993; Lederer & Sethi, 1996; Segars et al., 1988).

From the previous review we learned that the information systems literature has evolved from focusing on the individual to focusing on the organization. As a component of the organization, IS scholars insist that the IS function play a strategic role and be integrated into the business plan. Though the existence of SISP is considered important, evidence shows that long and costly planning processes are counterproductive while dynamic and emergent planning processes are ideal (Hackney et al., 2000; Mintzberg, 1994). As part of the development just outlined, Cohen & Levinthal (1990) introduced absorptive capacity defining it as the firm's ability to recognize the value of new external

information, and be able to assimilate and apply the information to commercial ends. A critical element of absorptive capacity is its cumulative effect because over time absorptive capacity escalates and becomes an important factor in improving efficiency over subsequent periods (Cohen & Levinthal, 1994).

Absorptive capacity is the company's pre-existing ability to be susceptible to external information by being able to recognize opportunities as they present themselves (Hamel & Prahalad, 1994; Van den Bosch et al., 1999). A firm can develop their absorptive capacity by increasing a firm's ability to acquire and assimilate external knowledge (Zahra & George, 2000). Kim (1998) categorizes Hyundai's catching up with technology process in several learning stages, which begins with preparation for the adoption of a technology before its acquisition. Several preparatory measures include the hiring of experienced personnel from outside the company, extensive literature search, observation of technology in operation, and temporary hiring of foreign engineers. This preparation stage will increase absorptive capacity.

The literature reveals a comprehensive list of elements comprising absorptive capacity that includes: 1) a firm's level of prior related knowledge, 2) diversity in background of employees, 3) research and development, 4) transfer of knowledge between departments, 5) balance between internal and external communication patterns, 6) commonality of knowledge between members within and among departments, 7) organizational structure, 8) a firm's compensation policies, and 9) breadth of knowledge. The following section explains each of these elements of absorptive capacity.

Elements Comprising Absorptive Capacity

Firm's level of prior related knowledge

A firm's level of prior related knowledge is cited as one of the most important factors determining absorptive capacity (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Lane et al., 2001) and, a minimal amount of prior knowledge that is basic to the new knowledge must be held. Having an understanding of the basics gives a learner more appreciation of newer more specialized knowledge. A learner who already has a basic understanding of the new technology has greater potential to learn the new technology.

Research on cognitive structures indicates that an individual's learning is greatest when the new knowledge is related to the individual's knowledge base and firms can prepare for a new technology through training (Lane & Lubatkin, 1998). One would expect if a company actively pursues a strategy to increase the absorptive capacity of the company that this would add to the prior experience with the technology. This is supported through the literature suggesting that absorptive capacity is built on prior investments in its member's individual absorptive capacity (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Lane et al., 2001; Szulanski, 1996; Van den Bosch, 1999). As an example, Hyundai Company, a South Korean auto manufacturer entered the auto industry in 1967 and increased its production ten-fold every decade becoming the 13th largest producer in the world by 1994 (Kim, 1998). Hyundai took preparatory measures to increase its prior knowledge of a new technology by obtaining experienced personnel from outside the firm who had experience with the technology, conducting an extensive

search of the literature on the technology, observing the technology in operation, and then hiring of foreign engineers who were well versed in the technology (Kim, 1998).

Diversity in background of employees

Research indicates that the particular composition of a group makes a difference in performance. Diversity can be defined by gender, age, culture, education, and area of expertise. Findings show diverse groups have trouble communicating with one another in the initial stages of group development. Once a structure of communication is developed, however, there is more generation of ideas making diverse groups therefore, better suited for creative problem solving (Cohen & Levinthal, 1990; Watson et al, 1993;). Some research (Bantel & Jackson, 1989; Watson et al., 1993) supports that heterogeneous groups are more innovative and creative than homogeneous groups. Diverse groups can improve performance by communicating key information such as the recognition of expertise in different areas. A group's awareness of the distribution of expertise within the group increases the sharing of uniquely held information (Stasser et al., 1995). Stasser and Titus (1987) suggest that diverse groups whose members possess different information may be more likely to discuss uniquely held information than groups composed of similar members (Stasser & Titus, 1987).

Research and Development

Researchers (Cohen & Levinthal, 1989, 1990, 1994; George et al., 2001;Rocha, F., 1999; Stock et al., 2001) have operationalized the absorptive capacity construct by using a firm's research and development (R&D) efforts as a proxy. A firm's ability to exploit external knowledge is often generated as a byproduct of its R&D, which satisfies two functions: it generates new knowledge and contributes to a firm's absorptive capacity

(Cohen & Levinthal, 1990). With regard to R&D, research has provided evidence to support that conducting internal R&D is an important complement to knowledge that is bought or acquired through contracts (Cohen & Levinthal, 1994; Mowery, 1983; Stock et al., 2001).

Transfer of knowledge between department

Knowledge located within a firm can be exchanged between departments in terms of direction, policies, procedures and manuals. Rules, regulations, instructions, and communications formalized in written documents and formal systems positively affect interdepartmental communications (Boyton et al., 1994). Information systems facilitate the need of communication and coordination among subunits and positions, but being able to learn from all other units in the same organization is not always an automatic process. A unit may want to obtain knowledge from other units but may not be able to access it. Even though the knowledge is available, the unit may not have the capacity to absorb and apply it to its own use.

Balance between internal and external communication patterns

"By building relation-specific assets, knowledge sharing routines and effective relational governance mechanisms into relationships, firms can leverage their relational resources for knowledge acquisition and exploitation," (Renko et al., 2001, p. 590). Social capital is a term used to describe a resource derived from social interaction, relationship quality, and network ties. Renko et al. (2001) argue that social capital facilitates knowledge acquisition and exploitation by affecting conditions necessary for value creation through the exchange of intellectual resources (Renko et al., 2001). Their

study added support for the notion that fostering close, intensive information exchanges facilitates learning.

Commonality of knowledge between and among departments

Cross-function interfaces such as relationships, contacts and liaison roles within departments reflect commonality of knowledge (Van de Bosch et al., 1999). In Japan companies make a conscious effort to overlap company information, business activities, and managerial responsibilities (Nonaka, 1991). This could be seen as unnecessary redundancy to US managers, but according to Nonaka (1991) this encourages frequent dialogue and creates a common cognitive ground facilitating the transfer of tacit knowledge (Nonaka, 1991).

Organizational Structure

"A flexible (non-bureaucratic, non-hierarchical) organizational structure and approach to management is thought to be associated with higher capacities for knowledge acquisition," (Lyles & Salk, 1996, p. 881). Structure operationalized as decision centralization and process formalization has been shown to be negatively related to dynamic problem solving behaviors (Brown & Eisenhardt, 1997; Child & McGrath; 2001; Cukrowski & Baniak, 1999; Forte et al., 2000; Rindova & Kotha, 2001). Organizational form is strongly related to a firm's knowledge processing activities (Kogut & Zander, 1996; Van den Bosch et al., 1999).

Firm's compensation policies

Social Learning Theory (SLT), according to Bandura (1977), states that learning occurs by the effect reinforcement has on behavior and by imitating or modeling the behavior of others. SLT explains that the learner develops an association between

behavior and consequence, even without direct, actual experience. The four main concepts in SLT are: attention, retention, reproduction and incentives. Attention is important because the learner must first notice the behavior he wishes to learn, before modeling it. Retention is the transformation of the modeled behavior into the learner's memory. Reproduction involves a repetition of the learned behavior from what the learner has stored in memory and a learner is motivated to continue to perfect the reproduction process by incentives. Bandura (1977) argues that behaviors that are not rewarded will not be reproduced. The fourth level of SLT is incentives. A firm's compensation policies can provide motivation that encourages the development of expertise that will result in new ideas (Shaw et al., 2001).

Breadth of knowledge

Non-superficial expertise must be developed to establish a sufficient level of specialization to incorporate a new technology. This could be seen as enactive mastery in the self-efficacy construct, a key element in SLT, which refers to an individual's belief in his or her capability to perform a specific task. The relationship between task performance and self-efficacy has been well established in the IS literature (Burkhardt & Brass, 1990; Compeau & Higgins, 1995; Marakas et al. 1998). Training programs enhance performance of a specific task and thereby enhance self-efficacy that then enhances performance in a reciprocal nature. The cycle continues until the individual "no longer actively performs an effortful, conscious analysis of CSE [computer self-efficacy]," (Marakas et al., 1998, p. 141). At this point the action is completely internalized into a routine with predictable outcomes in performance.

Self-efficacy is a dynamic construct and reflects more than ability assessment. It is also a reflection of motivational and integrative aspects. Self-efficacy forms a critical influence on future intentions and according to Bandura (1977) there are four primary antecedents for self-efficacy judgments. From most important to least important these are (1) enactive mastery (2) vicarious experience (3) verbal persuasion and (4) emotional arousal.

Enactive mastery is the acquiring or mastering of a skill through training and use. Vicarious experience is the process of acquiring second-hand experience. It is an organization's attempt to learn about the strategies, administrative practices and especially technologies of other organizations (Huber, 1991). Another term used for this is corporate intelligence. Channels used to capture this vicarious experience or corporate intelligence include consultants, professional meetings, trade shows, publications, vendors and suppliers, and networks of professionals (Huber, 1991). Verbal persuasion by a reliable and credible expert is viewed as support or encouragement. Emotional arousal is tied to computer anxiety and computer phobia and high levels of arousal are associated with reduced computer performance. There is a cycle of anxiety in a computer setting that increases resistance or even fear toward computers (Marakas et al., 1998). Anticipatory self-arousal (Bandura, 1977) needs to be controlled through direct anxiety-reducing mechanisms.

The social knowledge controlled by an individual within an organization is greatly reduced through division of labor. As an individual becomes more competent within a specialization, the less informed his general knowledge becomes. This

specialization, however, is good for the organization, as long as the firm is efficient in its coordination (Kogut & Zander, 1996).

The preceding elements will be combined in order to obtain an absorptive capacity measure. Subsequent analyses will determine the impact absorptive capacity will have on each of the levels of organizational learning and its indirect effect on firm performance.

It should be noted, for the benefit of a better understanding of the concept, that absorptive capacity and TAM, see Figure 3, have parallel constructs; yet, absorptive capacity includes communication and coordination aspects of members within an organization. TAM is an individual level construct and though it is useful in predicting an individual's propensity to successfully adopt a technology, it falls short of predicting a *firm's* propensity to successfully adopt a technology. Instead, absorptive capacity is an organizational level construct that measures a firm's ability to recognize the value of external knowledge, assimilate it, and exploit it. The two main predictors in the TAM model are perceived usefulness and perceived ease of use (Davis, 1986). Parallel to TAM's perceived usefulness construct, is absorptive capacity's recognition that the firm must first recognize the value of external knowledge. Yet, the firm as a whole must perceive the usefulness of the technology, which implies that there is management support and that the technology is part of a strategic intent (Nonaka & Takeuchi, 1995). To amplify TAM's second construct, perceived ease of use, from an organizational perspective it is necessary to gauge how technologically feasible it is for an organization to embark on technology adoption projects. Perceived usefulness and perceived ease of

use are captured through variables indicated in the literature that measure absorptive capacity.

Organizational Learning As A Firm Level Construct

Definition

Organizational learning is not merely the sum of individual learning, but rather, the creation of knowledge and its distribution through communication across the company (Kim, 1998). Organizations learn only when individual insights and skills become embodied in organizational routines, practices, and beliefs (Attewell, 1992). When conducting research in an effort to predict the success of information systems in firms, it is necessary to use organizational level constructs. Constructivist approaches regard learning and understanding as an "active process during which learners question, manipulate, elaborate, organize, and monitor their progress so that learning makes sense to them," (Abrami, 2001, p.119). The learning environment provides the context in which learning takes place. Context may have a significant bearing on skill mastery, execution and transfer (Blaxton, 1989).

The replication of internal processes in one area to another area of the company is a process that involves stages. Knowledge transfer occurs in a shared social context in which different units are linked to one another. According to Szulanski (1996), the four stages are initiation, implementation, ramp-up, and integration. The initiation stage is when a superior performance is found in one area of the company and thereafter the possibility of transferring this best practice is entertained. Once the decision is made to transmit the best practice, then the implementation phase begins and continues until the

receiving area of the company begins to actually use the new practice. In the ramp-up stage, the recipient of the new practice begins to learn and perform until it reaches a satisfactory level of performance. Finally, in the integration stage the conveyed knowledge becomes more of a routine and in fact the new process becomes institutionalized and taken for granted (Sulanski, 1996).

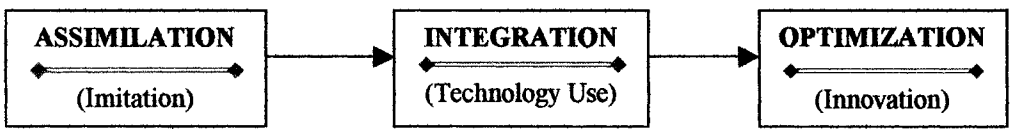
The stages in the transfer-of-best-practices process are important because if restated using a little different terminology could be used as the four stages in organizational learning. Organizational learning takes place through the interaction of two dimensions of knowledge: tacit and explicit knowledge. Tacit knowledge is deeply rooted in an individual's mind. It is hard to codify and communicate and can be expressed only through action, commitment, and involvement in a specific context. Tacit knowledge is the core of a firm's prior knowledge base (Kim, 1998; Nonaka, 1991; Osterloh & Frey, 2000). Explicit knowledge is knowledge that can be codified and transmittable in formal, systematic language. The four conversion processes are:

1. Tacit to Tacit- socialization or training interaction where one individual shares information to another individual.
2. Explicit to Explicit- gathering and synthesizing information from many sources, creating one new whole document such as a financial report
3. Tacit to Explicit-or externalization of tacit knowledge in the form of a new approach.
4. Explicit to Tacit- or internalization of explicit knowledge as it is shared throughout the firm to other individual members. It is used to broaden and reframe an individual's own tacit knowledge until the new approach is taken for granted.

Stages of Organizational Learning

The three stages in organizational learning, as proposed in this dissertation, are assimilation, integration, and optimization. These stages are consecutive. The integration stage is not attained before assimilation, and the optimization stage is not attained before integration. Assimilation refers to the stage beginning after the acquisition or purchase of a new technology. A firm in this stage is in the imitation phase of organizational learning. Integration is the actual using of the technology in the learning-by-doing phase including problem solving. Optimization is the innovation stage where new knowledge is created. "The essence of innovation is to re-create the world according to a particular vision or ideal. To create new knowledge means quite literally to re-create the company and everyone in it in a nonstop process of personal and organizational self-renewal," (Nonaka, 1991, p. 97). Figure 4 illustrates the relationships between these terms.

FIGURE 4. Stages in Organizational Learning



Assimilation

Assimilating knowledge requires active engagement of the learner. Lane, Salk and Lyles (2001) state that one corrective element from their previous model was the inclusion of an additional component, parallel to the ability to *understand* external knowledge and before the ability to *apply* new knowledge. This new construct is the

ability to *assimilate* knowledge. Lane et al. (2001) developed a model that depicts a path towards learning and performance in international joint ventures (IJV). These researchers divide the capacity of placing value on external knowledge into two components: the ability to *understand* external knowledge and the ability to *assimilate* external knowledge. These two are antecedents to knowledge learned from a foreign parent. A third component the ability to *apply* external knowledge is then introduced which leads to IJV performance. Flexibility and other learning structures and processes influence the assimilation of foreign knowledge (Lane & Lubatkin, 1998). The ability to assimilate external variables is measured through flexibility, adaptability, management support, training, formal goals, and specialization (Lane et al., 2001).

The literature on innovation diffusion of technology indicates that imitation is an important first stage in the assimilation process. "Because of interconnectivity between firms and the standardized nature of equipment and procedures used, numerous channels exist for the quick dissemination of information of each others' experiences," (Majumdar & Venkatraman, 1998). Imitative behavior is seen as positive because a company economizes in the process of decision-making. In an ambiguous, constantly changing environment, imitating is a decision with less risk.

Linsu Kim (1998) analyzes Hyundai Motor Company and develops a model of organizational learning as an imitative catching-up process and crisis construction. Kim (1998) notes that innovation in less developed countries such as South Korea does not necessarily mean developing innovative cutting edge technology, but rather innovation that comes in a catching-up process where firms try to avert or overcome a crisis by updating their technologies, or by imitating efforts of firms in more technologically

advanced countries. Kim(1998) develops the concept of absorptive capacity in a 2 x 2 matrix where the Y-axis measures the level of prior knowledge base and the X-axis measures intensity of effort.

Integration

Exposure to relevant external knowledge is insufficient unless an effort is made to integrate that knowledge (Kim, 1998). Internalization comes from developing experience over time with explicit knowledge that eventually becomes part of orientation procedures and general routines (Lyles & Salk, 1996). Assimilation is learning by doing and learning by using (Kim, 1998). Kaounides (1999) sees the necessity for firms to acquire a wider set of in-house multidisciplinary capabilities and core technological competencies. He argues that organizational learning is an antecedent to the internalization of new techniques into new components, devices, systems, products, and services that cut across traditional industry boundaries (Kaounides, 1999). An individual organizational unit can access new knowledge through a network of inter-unit links (Hansen, 1999).

Capacity, response time, throughput rate, overhead percentage, software time measures, reliability measures, system utilization measures, raw speed, and availability are the most common variables used for operationalizing efficiency. Huber (1990) provides comprehensive lists for measuring efficiency. In the context of decision-support systems, the properties of efficiency in advanced information technologies include those that facilitate an individual or organization to:

- store and retrieve large amounts of information more quickly and inexpensively,
- more rapidly and selectively access information created outside the organization,
- more rapidly and accurately combine and reconfigure information so as to create new information,

- more compactly store and quickly use the judgment and decision models developed in the minds of experts, or in the minds of the decision maker, and stored as expert systems or decision models,
- more reliably and inexpensively record and retrieve information about the content and nature of organizational transactions.

In the context of communication, the properties of efficiency in advanced information technologies include the facilitation of an individual or organization to:

- communicate more easily and less expensively across time and geographic location,
- communicate more rapidly and with greater precision to targeted groups,
- record and index more reliably and inexpensively the context and nature of communication events,
- more selectively control access and participation in a communication event or network (Huber 1990).

Optimization

Optimization, defined as the ability to apply external knowledge, is comparable to Kim's improvement/ application stage of incremental improvements and their application to other areas (Kim, 1998). Similarly, in a study by Venkatraman (1994) five levels of IT enabled transformation are identified. Venkatraman argues that performance will improve as a firm is categorized into higher levels of transformation. "While the higher levels of transformation indicate potentially greater benefits, they also require a corresponding higher degree of changes in organizational routines," (Venkatraman, 1994, p. 74). Venkatraman's (1994) fourth level of IT enabled transformation is business network redesign. This level is achieved when information systems and technologies involve more than one organization. Electronic data interchange is an antecedent to this level because it addresses the network and data interchange issues. The extra step, however, comes in the redesigning of processes to take advantage of the data interchange. Information networks share knowledge, like concurrent engineering, and just-in-time inventory management

processes. These networks are not available to all companies but come in the form of strategic alliances and partnerships. Information technology has a distinct role in enabling, creating, and maintaining a flexible business network. Venkatraman's (1994) fifth level is business scope redefinition. This level is achieved when IT enables the firm to provide a new dimension in their business scope. In this level firms venture into new types of services never offered before by anyone and they are made possible by new technological advances.

Lane et al. (2001) measured optimization through the variables of business strategy, and training competence. In addition to the variables used in Lane et al. (2001), this research includes the network variable. Network ties provide access to resources. The role of the network is to provide an efficient screening and distribution process for members of the network (Nahapiet & Ghoshal, 1998). "Network ties influence both access to parties for combining and exchanging knowledge and anticipation of value through such an exchange" (Nahapiet & Ghoshal, p.251). Venkatraman's (1994) level four of IT enabled transformations is network redesign. The ability to become part of an information network will also be used in this research as a variable in the optimization construct.

Inter-unit links and networks are an important part of a learning process in which organizational units discover new opportunities and obtain new knowledge through interacting with one another. Networks form as firms embed themselves in relationships (Szulanski, 1996) with designers, suppliers, subcontractors, customers, and other networks. These relationships may in turn become strategic if both firms seek a common goal and decide to cooperate instead of compete. Network processes, therefore, become

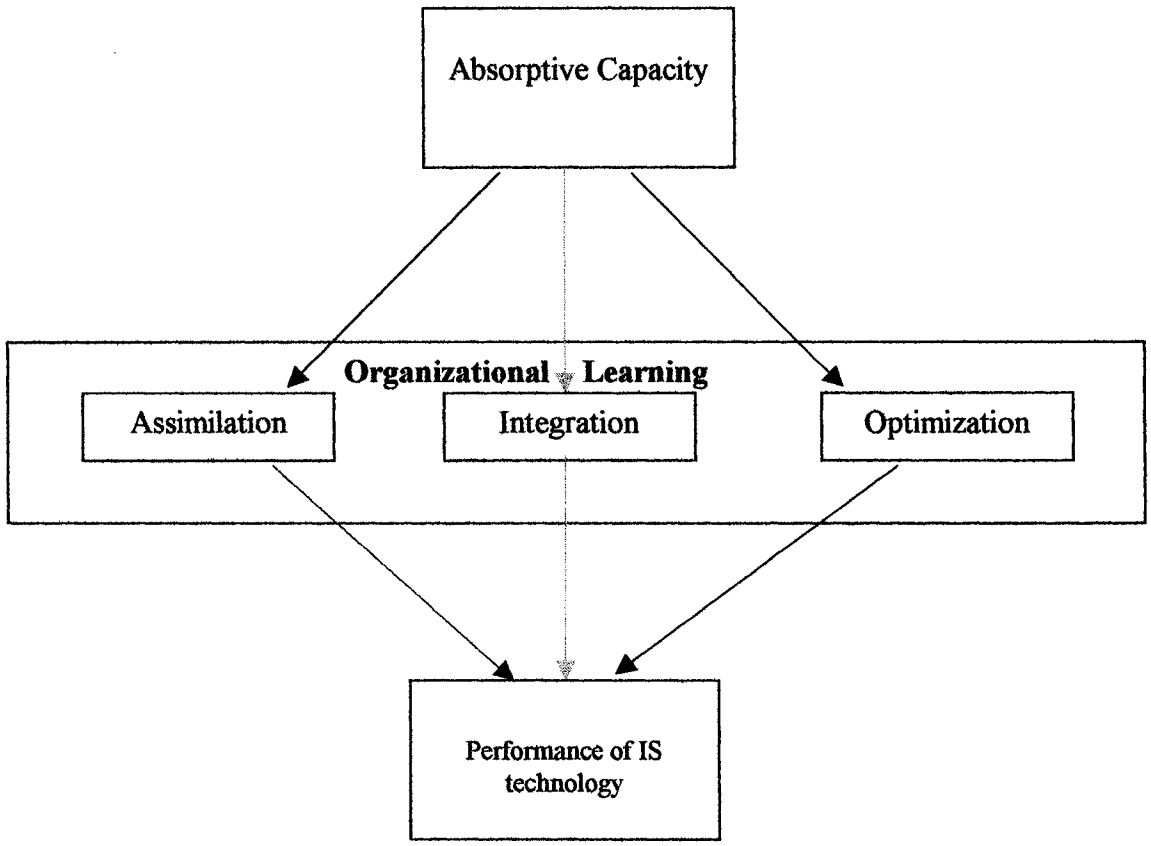
the optimum level of sustained competitive advantage. "If our modern world is one dominated by organizations with specialized contributions, scholars are beginning to recognize that it is by necessity also one dominated by connections among these specialized entities" (Osborn & Hagedoorn, 1997, p. 261).

"Innovation networks incorporate formal and informal linkages which are established within and across organizational boundaries as a means of capturing codified knowledge represented in specifications, reports and software as well as tacit knowledge which can only be communicated by direct social interaction," (Jones & Craven, 2001, p.3). A change in one component might cause a change in behavior or performance of another component (Majumdar & Venkatraman, 1998). Therefore, the interdependence between different components or members provides a flexible learning structure that replaces old hierarchical structures (Huber, 1991;Tsai, 2000).

Relationships

The relationships between absorptive capacity, organizational learning and performance are illustrated in Figure 5, which represents the research framework for the dissertation. A path begins from absorptive capacity to organizational learning, but because organizational learning is divided into three stages there are three separate paths. Each of these paths leads to each level in organizational learning: assimilation, integration and optimization. A major component of this research is the continuation of the path analysis from each of the stages of organizational learning towards the performance of the adopted technology.

FIGURE 5. Dissertation Study Conceptual Model



The model presented in this dissertation advances the theory a step by actually combining all relationships in one single model. It is important to highlight, however, that the relationship between absorptive capacity, organizational learning, or improved performance are not automatic (Zahra & George, 2000). The relationships between absorptive capacity and the stages of organizational learning (assimilation, integration and optimization) leading towards performance are formulated as follows:

Hypothesis 1:	Absorptive capacity, when mediated by assimilation, has no impact on performance.
Hypothesis 2:	Absorptive capacity, when mediated by integration, has a positive impact on performance
Hypothesis 3:	Absorptive capacity, when mediated by optimization, has a positive impact on performance and the size of the effect will be greater than that of integration.
Hypothesis 4:	The total mediating effect of organizational learning between absorptive capacity and performance is above average and positive.

This chapter has presented a literature review of the absorptive capacity construct including a history in IS literature that has led to the development of this construct. The absorptive capacity literature is followed by the review of the organizational learning literature and how this literature points to the categorization of three different stages in organizational learning. It is theorized that higher levels of absorptive capacity will lead to higher levels of organizational learning. The hypotheses presented in this dissertation represent a continuation of the path analysis from absorptive capacity to organizational learning to performance of the adopted technology. The next section explains the methodology for conducting the research illustrated in the model.

CHAPTER III

RESEARCH METHODOLOGY

The research framework for this dissertation leading to the research hypotheses was developed in the previous chapter. In this chapter, the sample is described and it includes a description of the directory from which the sample was taken. Detailed in this chapter are the results of the pilot study. The chapter continues with the measurement items for both the dependent and independent variables. The chapter ends with an explanation of statistical methods that were used to test the hypotheses. The appropriate methodology for conducting the research is examined in the next section of this chapter.

Sample

Population

The population in this dissertation is top-level Information Systems (IS) executives in the US or Canada employed in firms who have implemented enterprise resource planning software. Enterprise Resource Planning (ERP) has the capability to join disparate data sources and make them available across enterprises in an organized, personalized, secure, and searchable fashion. ERP integrates key business and management processes to provide a comprehensive view of an organization. The unique idea behind ERP is that software needs to communicate across functions and therefore, it includes financial, human resources and manufacturing information. Every step in

inventory management from receiving to shop floor placement to printing an accounts payable check is handled immediately by ERP software. Similarly the accounts receivable module can generate an invoice as soon as the shipping clerk says the finished goods are on the truck to the customer. All this is done with minimal paperwork or human intervention. ERP aims to replicate business in software and automate as many procedures as desired (Slater, 1999). The number one vendor in ERP software providers with 35% of the market is the German-based SAP. Other ERP providers include Oracle, People Soft, J.D. Edwards and others.

Sample Frame

The sampling frame includes IS executives who indicated they were ERP users in the 2002 Directory of Top Computer Executives published by Applied Computer Research, Inc. The sample frame includes 3,244 executives employed in private firms. The Directory lists the top-ranking individual over the IT function, such as the VP, Director, or Manager of Information Technology. In addition, second-level managers (which directly report to the top executive) including the Manager of Software Development, Manager of Operations, Manager of Data Communications, Manager of Microcomputers, and the Manager of Technical Support are also listed in the Directory.[1] Top-level executives are considered ideal for studies dealing with strategic, organizational and managerial issues because they are involved with planning on a broad scope (Segars et al., 1998).

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[1] The *Directory of Top Computer Executives* database was created in 1972 with the goal of covering the largest IT departments across the U.S. and Canada. For an organization to be listed, it must have a full-time VP, Director, or Manager of IT; have a multi-user host machine no smaller than an AS/400; or have more than 100 deployed desktop systems and an annual IT budget no smaller than $250,000. The primary focus is companies with more than 500 employees.

Sampling Unit

The sampling unit was the individual IS executive.

Measurements

Dependent (Endogenous) Variable

Performance is measured by a satisfaction rating in which the executive is asked to determine a general "satisfaction rating of the ERP project". This is a direct measure of a project's success as perceived by the top level IS executive surveyed in the study. The pilot study used a five-point scale ranging from minimal to superior satisfaction.

Independent (Exogenous) Variables

Absorptive Capacity Construct

The construct of absorptive capacity was measured with the items presented in Table 1. The pilot study used an adapted version of Szulanski's 9-Item scale that was empirically tested in his 1996 study with a reported alpha of 0.83. The first nine items used by Szulanski (1996) are included in Table 1. The tenth item was added because it is important to consider the pace of change as perceived by the executives that are interviewed. The rapid pace of change in the IS field has been a prevalent issue in the literature (Brown & Eisenhardt, 1997; Orlikowski & Hoffman, 1997). Items 11 through 17 have been strongly indicated in the literature as important aspects of absorptive capacity (Cohen & Levinthal, 1990). All 17 items represented the absorptive capacity construct in the pilot study. These items were added to create a summated score to test correlations, to use for independent t-tests used to determine non-response bias and to use in the pilot-study regression analysis.

TABLE 1. Measurement Items/ Scales for Absorptive Capacity

Construct: Absorptive Capacity *Uses a six point scale (-3= Strongly disagree,-2=Disagree, -1=Slightly Disagree, 1=Slightly Agree, 2=Agree, 3 =Strongly Agree)*		
Item	**Question(s) for Item**	**Reference**
Common Language	Users have a common understanding of technical language used by ERP project team.	Szulanski, 1996
Vision	There is a vision of what is trying to be achieved with ERP.	Szulanski, 1996
Latest Info	Users have been given information of state-of-the-art technology involving ERP.	Szulanski, 1996
Roles	There is a clear division of roles and responsibilities to implement ERP.	Szulanski, 1996
Skills	The necessary skills to implement ERP exist.	Szulanski, 1996
Tech Competence	There is technological competence to absorb ERP.	Szulanski, 1996
Managerial Competence	There is managerial competence to absorb ERP.	Szulanski, 1996
ID-expert	It is well known who can exploit new information provided through ERP.	Szulanski, 1996
ID-Problem Solver	It is well known who can help solve problems in ERP implementation.	Szulanski, 1996
Tech-Skills Uncertainty	The underlying skills associated with the IS function are rapidly changing.	Poppo & Zenger,1998
IT Uncertainty	The optimal configuration of hardware/software required to perform ERP is rapidly changing?	Poppo & Zenger,1998
Diversity	The ERP project team is composed of people from diverse areas of expertise.	
R&D	*R&D efforts are being conducted in ERP technology.*	*Modified Question*
Transfer	Departments are cooperating in the ERP implementation effort.	
Balance	The ERP project team has good relationships with outside experts in ERP.	
Structure	The organizational structure in this firm is best characterized as formal.	
Compensation	The firm's compensation policies provide motivation for the adoption of ERP.	

Assimilation Construct

Table 2 lists the 5 items for the assimilation construct. The ability to assimilate external knowledge is measured through the variables flexibility and adaptability, management support, training, formal goals, and specialization (Lane et al., 2001). Adaptability and management support and formal goals have multiple questions. These items were added to create a summated score to test correlations, to use for independent t-tests used to determine non-response bias and to use in the pilot-study regression analysis.

TABLE 2. Measurement Items/ Scales for Assimilation

Construct: Assimilation *Uses a six point scale (0=No Extent; 1=Little Extent; 1.5=Some Extent; 2=Fair Extent; 2.5= Above Average Extent and 3 =Great Extent)*		
Variable Name	**Question(s)**	**Reference**
Flexibility and Adaptability	To what extent is the organization flexible? To what extent is the organization adapting to change? To what extent is the organization creative?	Lyles & Salk, 1996 Alpha .67
Management Support	To what extent do superiors know about project team's performance? To what extent do superiors contribute managerial resources to project? To what extent do superiors contribute administrative support? To what extent do superiors contribute emotional support? To what extent do superiors provide for training for the project team? To what extent do superiors provide time to the project team?	Lyles & Salk, 1996 Alpha .82
Formal Goals	Does the ERP project have written objectives? (yes/no) Measured in years, to what extent does the ERP project have long term plans?	Lyles & Salk, 1996

Integration Construct

Table 3 shows the four measurement items for the integration construct. The characteristics of knowledge integration are measured by three variables: efficiency, scope and flexibility (Grant, 1996; Van den Bosch, 1999). Efficiency refers to how firms identify, assimilate and exploit knowledge from a cost and economies of scale perspective. Scope is defined as the breadth of component knowledge a firm draws upon. Flexibility is the extent to which a firm can access additional, and reconfigure existing, explicit and tacit knowledge within an organization. Efficiency and scope have multiple questions and one question identifies economies of scale. These items were added to create a summated score to test correlations, to use for independent t-tests used to determine non-response bias and to use in the pilot-study regression analysis.

TABLE 3. Measurement Items for Integration

Construct: Integration *Uses a six point scale (-3= Strongly disagree,-2=Disagree, -1=Slightly Disagree, 1=Slightly Agree, 2=Agree, 3 =Strongly Agree)*		
Variable	**Question**	**Reference**
Data Quality	The new ERP technology provides more accurate data. The new ERP technology provides more comprehensive data. The new ERP technology provides more correct data. The new ERP technology has improved the consistency of data.	Wixom & Watson, 2001 Fornell .84
Flexibility and Scope	The new ERP technology can flexibly adjust to new demands or conditions. The new ERP technology integrates data from systems servicing different functional areas. The new ERP technology is versatile in addressing needs as they arise. The new ERP technology integrates data from a variety of data sources within organization.	Wixom & Watson, 2001 Fornell .86
Economies of Scale	There is sufficient scale in our operations to perform ERP efficiently in-house.	Poppo & Zenger, 1998

Optimization Construct

Table 4 displays the 3 items used to operationalize the optimization construct. It is measured by the variables: business strategy, and training competence proposed by Lane et al. (2001). In addition to these two variables used in Lane et al. (2001), this study also included the network variable.

TABLE 4. Measurement Items for Optimization

Construct: Optimization *Uses a six point scale (0=No Extent; 1=Little Extent; 1.5=Some Extent; 2=Fair Extent; 2.5= Above Average Extent and 3 =Great Extent)*		
Item Name	**Question**	**Reference**
1. Business Strategy	To what extent has management emphasized new products? To what extent has management had promotion and advertising expenses above industry average? To what extent does the firm have extensive customer service capabilities? *To what extent does the firm have an influence over the channels of distribution?*	Lane et al., 2001 Alpha .75 *New Question*
2. Training Competence	To what extent is the prior year's user training effective? To what extent are ERP skills among users improving? To what extent has the new ERP technology brought added in-house expertise? To what extent does the firm have highly trained personnel in the IT department? *To what extent are new ERP skills improving the competitiveness of the firm?*	Lane et al., 2001 Alpha .72 *New Question*
3. Network	To what extent has the sharing of information between departments increased through ERP?	Boynton et al., 1994

Pilot Test

A pilot test with a sample of 300 companies was used to refine the survey methodology in order to assess its internal validity and to determine an expected response rate. Of the 300 randomly selected companies, 250 were from the US and 50 were from Canada. Data was collected for a period of one month. Table 5 describes the industry classification of the companies in the study. The manufacturing industry comprised 83.4% of the respondents.

TABLE 5. Industry Classification for Pilot Study

Industry	Frequency	Percent
Banking and Finance	4	1.3
Insurance	5	1.7
Manufacturing	251	83.7
Retail	18	6.0
Transportation	3	1.0
Utilities	12	4.0
Other	7	2.3
Total	300	100.0

The 300 pilot study surveys were mailed on December 7, 2002. A copy of the cover letter is included in Appendix A.

Response Rate

One of the main reasons for conducting the pilot study was to establish an expected response rate to calculate the amount of mail-outs needed for the main study. There were 26 completed surveys returned, giving an 8.6% response rate. There were 5 additional responses that were unusable either because they were incomplete or the executive indicated they were unable to complete the survey for various reasons. Assuming the 8.6% response rate achieved in the pilot study mailing, 253 responses were

expected to return from the main study. A 10 to 1, subjects to parameter ratio, is appropriate (Kline, 1998) but a more typical 5:1 ratio (Hair et all, 1998) is expected for the 2,943 surveys mailed out. Because this study consists of 31 parameters, a minimum sample size of 155 is required.

Research Instruments

A second major reason for conducting the pilot study was to test the instruments reliability. After receiving 26 completed questionnaires and comments made by the respondents several corrections were made to the questionnaire. There was one question modified in the absorptive capacity scale, one question added to the strategy scale and one question added to the training scale. There were no changes in the assimilation or integration scale items. Table 1 shows the new wording for the R&D item in the absorptive capacity scale, which now reads, "R&D efforts are being conducted in ERP technology." Table 4 shows the new questions: "To what extent does the firm have an influence over the channels of distribution?" added to the strategy scale and "To what extent are new ERP skills improving the competitiveness of the firm?" added to the training competence scale. In addition, because there were practically no responses for the sales and profit sections, these were eliminated. The question, "Does the firm have a broad product line?" was also eliminated because it was confusing to the respondents.

Reliability

Table 6 shows the reliability scores, means and standard deviations for all the scales used in the pilot study. The absorptive capacity scale had an alpha of .9188. The scales used in the assimilation construct are flexibility and adaptability (.8647 alpha) and the management support scale (.9404 alpha). The integration construct includes the data

quality scale (.9509 alpha) and flexibility and scope (.8647 alpha). The training competence scales had an alpha of .8033 and the business strategy scale an alpha of .7296. The pilot study reliability test for the business strategy scale shows that eliminating the question "Does the firm have a broad product line" improves the reliability score. All the reliability scores have shown the content validity of the scales are above the .70 alpha benchmark recommended as a minimum alpha measure for confirmatory analysis (Nunnally, 1978).

TABLE 6. Pilot Study Survey Scale Measures

Absorptive Capacity

Alpha: .9188

	ITEM	MEAN	STD DEV	Cases
1	COMMLANG	0.0000	1.6248	26
2	VISION	1.5000	1.5033	26
3	INFO	0.3846	1.7906	26
4	ROLES	1.4231	1.6775	26
5	SKILLS	0.9615	1.9694	26
6	TECHCOMP	1.1154	1.6811	26
7	MANACOMP	0.7692	1.8613	26
8	EXPLOIT	0.5000	1.7944	26
9	PROBLEM	0.7692	1.8613	26
10	SKILLCHG	1.7308	1.5115	26
11	ITCHANGE	0.7692	1.9454	26
12	DIVERSE	2.0385	1.3411	26
13	RD	-1.0385	1.6848	26
14	TRANSFER	1.3077	1.5171	26
15	BALANCE	1.4615	1.7716	26
16	FORMAL	-0.5769	2.0035	26
17	COMPENSA	-1.3077	1.4358	26

Integration

Data Quality

Alpha: .9509

	ITEM	MEAN	STD DEV	Cases
1	ACCURACY	1.4615	1.5292	26
2	CMPRHND	2.0385	1.1129	26
3	CORRECT	1.5000	1.4491	26
4	CONSIST	1.6923	1.3496	26

Flexibility and Scope

Alpha: .8647

1	FLEXIBLE	0.7308	1.6139	26
2	INTGSYST	1.7692	1.2428	26
3	VERSATIL	0.9615	1.5095	26
4	INTGSOUR	0.8846	1.7047	26

Assimilation

Flexibility and Adaptability

Alpha: .8342

1	FLEX	1.7115	0.5861	26
2	ADAPT	1.7115	0.7235	26
3	CREATIVE	1.5769	0.5602	26

Management Support

Alpha: .9404

1	SUPPORT1	1.8462	0.7585	26
2	SUPPORT2	1.9038	0.7351	26
3	SUPPORT3	1.7308	0.6961	26
4	SUPPORT4	1.7692	0.8152	26
5	SUPPORT5	1.8269	0.8825	26
6	SUPPORT6	1.7885	0.6808	26

Optimization

Training Competence

Alpha: .8251

1	TRAIN1	1.8462	0.4641	26
2	TRAIN2	1.7308	0.5519	26
5	STRATEG2	1.8846	0.7656	26

Strategy

Alpha: .6966

	ITEM	MEAN	STD DEV	Cases
1	STRATEG3	1.4000	0.8036	25
2	STRATEG4	0.9800	0.6690	25
3	STRATEG5	1.6000	0.8165	25
4	STRATEG6	2.1200	0.5824	25

Non-Response Bias

Non-respondents are those who were contacted but were unwilling to participate in the research. To make sure that the responses of those who did respond are representative of those who failed to respond, a wave analysis was conducted (Creswell, 1994; Dillman 1978). Once data was collected for the main study, non-response bias was

determined by comparing summated scores for the absorptive capacity construct, the assimilation construct, the integration construct, the optimization construct and satisfaction rating of early responses to subsequent responses using wave analysis.

Cross Validation

Fitting the model to a given sample and then validating the solution by applying it to a second independent sample can obtain a solution for predictive accuracy. This is typically done by randomly splitting a sample into two sub-samples. The second fitting of the model will test the predictive accuracy of the first fitted model. If the second fitting is predicted by the first, then the reliability of the instrument is validated.

Regression Analysis

Path analysis is used to represent the relationship from absorptive capacity to organizational learning towards performance as shown in Figure 6. Preliminary regression analyses performed on the pilot study data provide support for the hypotheses and conceptual framework of this dissertation. The satisfaction rating was used as the dependent variable in a series of four regression equations. Absorptive capacity as the predictor of the satisfaction rating yielded an R-Square of .220 with a .018 significance. The interaction of absorptive capacity times assimilation when predicting the satisfaction rating yielded an R-Square of .241 at a .015 significance level. The interaction of absorptive capacity multiplied by integration did not produce significant results at the .05 level and the interaction of absorptive capacity multiplied by optimization gave an R-Square of .307 at a .005 significance level. The results provide support to the mediation of organizational learning stages between absorptive capacity and performance, by the stronger R-Square coefficients in the interactions, at least for assimilation and

optimization. In addition, the interaction between absorptive capacity and optimization was the strongest predictor. However, the small sample size is insufficient and probably explains the lack of significant results in the regression equation using the interaction of absorptive capacity and the integration construct as the predictors.

Methodology

An initial exploratory factor analysis test was conducted to test the reliability of the absorptive capacity construct measured by the items presented in Table 1. Confirmatory factor analysis was also performed on the multiple item responses in assimilation, integration, and optimization constructs. These scales have been previously used by Lane et al. (2001) and Lyles and Salk (1996). Structural Equation Modeling (SEM) provides a confirmatory factor analysis, a confirmation test of the scales already provided in the literature and a measure of internal consistency reliability of each construct to be assessed.

Factor Analysis

An exploratory factor analysis test done on the pilot sample data revealed the possibility of having four factors or dimensions that represent absorptive capacity. Examining the entire correlation matrix to determine the appropriateness of factor analysis, the Bartlett test of sphericity showed that nonzero correlations existed at the significance level of .0000 and the Kaiser-Meyer-Olkin measure of significance adequacy of .682 was in the mediocre range of adequacy, which is to be expected with a sample size of 26. The rotated (varimax) item loadings are presented in Table 7. A corresponding scree plot, presented as Figure 6, shows how these four factors have

eigenvalues greater than one. Questions loading into the first factor were "departmental cooperation," "clear division of responsibilities," and "relationship with outside experts;" hence, the factor was named structure. The second factor is comprised by the questions: "having a clear vision," "state-of-the-art technology," "technical competence," and "managerial competence," and consequently the factor was named leadership. The third factor was named motivation mechanisms because it includes the item "common understanding of technical language," "R&D," and "compensation policies." The fourth factor joins questions about "who can exploit the new information," "changing skills" and "changing IT technologies;" thus, the fourth factor was named change readiness. The total variance explained with the four factors was 73.666%, as shown in Table 8, along with the variance explained by each of the four factors.

TABLE 7. Rotated Component Matrix for Pilot Study

	Component			
	Structure	Leadership	Motivation	Change
Clear division of roles and responsibilities	.690	.556		
It is well known who can solve problems in ERP	.591			
Project team is composed of people from diverse areas of	.692			
Departments are cooperating in the ERP implentation	.705			
The project team has good relationships with outside experts in	.848			
The organizational structure is characterized as	.670			
Vision	.574	.591		
State-of-art		.651		
The necessary skills to implement ERP		.721		
There is technological competence to absorb		.733		
There is managerial competence to absorb		.856		
Users have a common understanding of the technical language used ERP project team			.676	
R&D efforts are being exercised in ERP			.807	
The firm's compensation policies provide motivation for adoption of			.761	
It is well known who can exploit information provided through				-.521
The underlying skills associated with the IS function are rapidly				.780
The optimal configuration of hardware/software to perform ERP is changing				.834

Extraction Method: Principal Component
Rotation Method: Varimax with Kaiser
a. Only loadings above 0.520 are shown

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.682
Bartlett's Test of Sphericity	Approx. Chi-Square	316.286
	df	136
	Sig.	.000

TABLE 8: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumula -tive %	Total	% of Variance	Cumula -tive %	Total	% of Variance	Cumula -tive %
Structure	7.794	45.850	45.850	7.794	45.850	45.850	4.094	24.083	24.083
Leadership	1.932	11.366	57.216	1.932	11.366	57.216	3.918	23.046	47.129
Motivation	1.545	9.087	66.302	1.545	9.087	66.302	2.516	14.803	61.932
Change	1.252	7.364	73.666	1.252	7.364	73.666	1.995	11.734	73.666

Extraction Method: Principal Component Analysis.

FIGURE 6: Scree Plot for Pilot Study Data

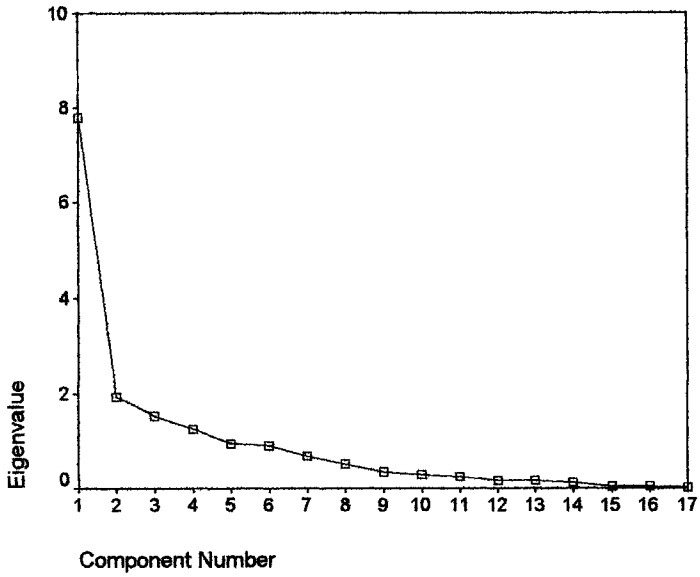


Table 9 shows the correlation matrix for these four factors of absorptive capacity. As noted in the table all inter-correlations are significant at to the .05 level.

TABLE 9. Factor Correlations of Absorptive Capacity

		Structure	Leadership	Motivation	Change Readiness
Structure	Pearson Correlation	1	.749**	.473*	.558**
	Sig. (2-tailed)	.	.000	.015	.003
	N	26	26	26	26
Leadership	Pearson Correlation	.749**	1	.491*	.634**
	Sig. (2-tailed)	.000	.	.011	.001
	N	26	26	26	26
Motivation	Pearson Correlation	.473*	.491*	1	.517**
	Sig. (2-tailed)	.015	.011	.	.007
	N	26	26	26	26
Change Readiness	Pearson Correlation	.558**	.634**	.517**	1
	Sig. (2-tailed)	.003	.001	.007	.
	N	26	26	26	26

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

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

Structural Equation Model

Structural Equation Modeling (SEM) was used to study the stipulated relationships in the hypotheses. One advantage of using SEM is that it allows for the entire research model to be tested at one time. Another advantage is that the magnitude of both direct and indirect effects is computed. The model presented in Figure 7 shows the path diagrams to be tested using SEM and Table 10 shows the correlations between the constructs created by using summated scales and performance as measured by the satisfaction rating of the ERP project.

FIGURE 7: Model for Absorptive Capacity

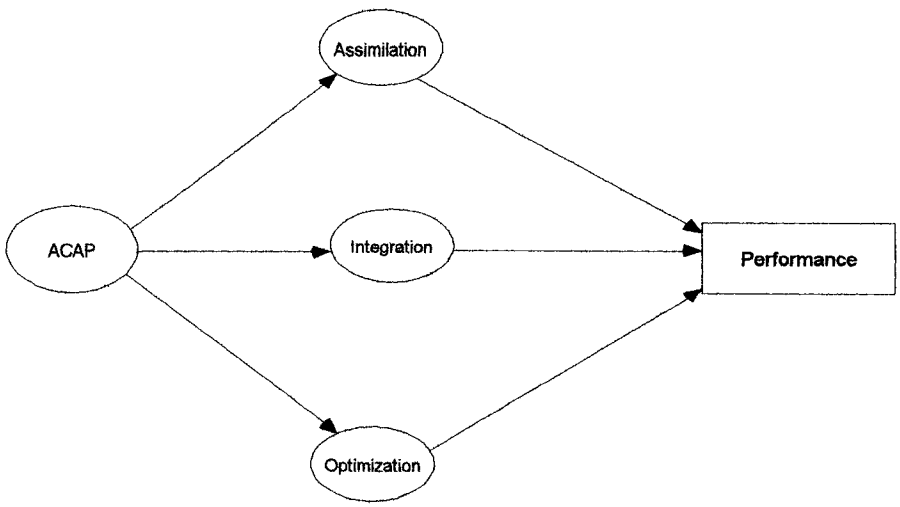


TABLE 10. Construct Correlations

		Absorptive Capacity	Assimilation Construct	Integration Construct	Optimization Construct	Satisfaction Rating
Absorptive Capacity	Pearson Correlation	1	.801**	.810**	.745**	.469*
	Sig. (2-tailed)	.	.000	.000	.000	.018
	N	26	25	26	25	25
Assimilation Construct	Pearson Correlation	.801**	1	.791**	.770**	.388
	Sig. (2-tailed)	.000	.	.000	.000	.061
	N	25	25	25	24	24
Integration Construct	Pearson Correlation	.810**	.791**	1	.773**	.612**
	Sig. (2-tailed)	.000	.000	.	.000	.001
	N	26	25	26	25	25
Optimization Construct	Pearson Correlation	.745**	.770**	.773**	1	.621**
	Sig. (2-tailed)	.000	.000	.000	.	.001
	N	25	24	25	25	24
Satisfaction Rating	Pearson Correlation	.469*	.388	.612**	.621**	1
	Sig. (2-tailed)	.018	.061	.001	.001	.
	N	25	24	25	24	25

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

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

The model is a hybrid model using confirmatory factor analysis and path analysis. Confirmatory factor analysis was done for the scales in order to test the factor's reliability. Subsequently, path analysis and goodness-of-fit measures identified the best-fit model. The research framework model, shown in Figure 7, was extended so that the absorptive capacity construct is a second order factor to include the four first order factors identified in the factor analysis. The assimilation, integration and optimization are second order constructs as explained in the literature review and measurements section of this chapter. Assimilation is composed of formal goals, management support, and flexibility of the firm. Integration is composed of data quality, scope, and flexibility of the IT project. Finally, optimization is composed of business strategy, training competence and the network variable.

This chapter has presented the results of the pilot study, which met with a response rate of 8.6%. Reliability scores for the scales are above the .70 recommended alpha level (Nunnally, 1978). Tables 1-4 contain the measurement items for the constructs of absorptive capacity, assimilation, integration and optimization, respectively. The tables also show the questions used in the questionnaire. To measure performance this dissertation uses an ERP project satisfaction rating. Structural equation modeling is used as proposed in the methods section. AMOS 4.0 is the software used for SEM because of the graphical interface that it uses.

CHAPTER IV

RESULTS AND ANALYSIS OF THE FINDINGS

This chapter presents the results and findings of the dissertation research. First the data is examined by calculating frequency distribution tables, means and standard deviations. A comparison test of significance in mean differences between segments of the population determines if there is response bias and whether there is a difference in absorptive capacity and organizational learning constructs between the United States and Canada. Exploratory factor analysis is used to analyze the interrelationships of the absorptive capacity construct because the pilot study questionnaire was revised to reflect suggestions and comments made by the pilot-study respondents. Confirmatory factor analysis is done as part of the measurement model in the structural equation model. Structural equation modeling (SEM) is the technique of choice for analyzing the path model proposed in this dissertation where there is a mediating effect of organizational learning between absorptive capacity and performance. The mediating effect is decomposed into the effect of each of the three organizational learning stages: assimilation, integration and optimization. The results then indicate if there is support or a lack of support for the hypotheses presented in Chapter II. Interpretation and implications of the findings, discussion and conclusions are presented in Chapter V.

Survey Methods

Questionnaires were mailed to the 2,943 top computer executives not surveyed in the pilot study. The Information Systems (IS) executives were given an option of responding by mail or completing an online survey. The cover letter, which is included in Appendix B, explains how to use the online option providing the Internet site address, username, password, and login instructions. The online survey was an exact replica of its hard copy version.

Data Assessment

Response Rate

A total of 264 responses were received, 128 envelopes were returned as undeliverable and 35 responded that they did not have an Enterprise Resource Planning (ERP) system in their organization. In total there were 264 responses from the 2,943 mailed surveys, which translates to a 9.5% response rate (calculated 264/2780). The response rate attained confirmed the expected response rate obtained in the pilot study.

United States versus Canada

The proportion of sample responses remained the same as with the population; 85% of the respondents were from the US and 15% from Canada. Differences in the mean of the summated scales for the constructs of absorptive capacity, assimilation, integration, and optimization did not prove significant at the .05 level for the two countries. Similarly, the Independent-Samples T-Test for Performance did not indicate a significant difference between the rating of the ERP project between US or Canadian IS executives. In SEM adding "country" as an exogenous variable leading into ACAP (absorptive capacity) yielded a standardized loading of .01, a loading that indicates a

virtually non-existent effect, which is also practically non-significant. Therefore, the conclusion is that the US and Canadian IS executives exhibit no differences in their perception of absorptive capacity, organizational learning and performance when using ERP.

Non-Response Bias

One important test to perform on the data was to see if there was non-response bias among the respondents. To test for non-response bias the data was separated into waves, the first wave being the early respondents and the second wave being the late respondents (Armstrong & Overton, 1977). The means of the summated scores for the absorptive capacity, assimilation, integration, optimization and the satisfaction variable of early responses were compared with the means of the late responses, and because the difference in means did not prove significant, non-response bias does not exist. An additional test was done to test for differences between those who chose to fill out the survey on paper compared to filling out the survey online. To determine if there was a bias between the two types of survey methods the means of the summated scores and the satisfaction variable were again tested for statistical differences. The 80 online responses representing 30% of responses, were compared to the 184 mailed responses and the means of each proved not significantly different at the .05 level. Therefore, there is no bias between those respondents answering via email compared to those who sent their questionnaires via posted mail.

Reliability

Table 11 shows the reliability scores, means and standard deviations for all the scales and sub-scales used in this research. The Cronbach Alpha measure of reliability

for the absorptive capacity construct was .8361. For the assimilation construct, the Cronbach alpha for the adaptability and flexibility subscale was .8269 and .8896 for management support. The values for the Cronbach alpha reliability coefficients for the integration construct were .9102 for data quality; .8581 for flexibility; and .7381 for scope. In the optimization construct the alpha scores were .7912 for business strategy and .7568 for training competence. All the reliability scores have shown the content validity of the scales is above the .60 Cronbach alpha benchmark recommended for exploratory factor analysis, and above .70 for confirmatory factor analysis (Nunnally, 1978).

TABLE 11. Sub-Scale Measures for Assimilation, Integration and Optimization

Assimilation			
Flexibility and Adaptablility			
Alpha: .8269			
	MEAN	STD	Cases
AS1	1.880	0.588	263
AS2	1.926	0.589	263
AS3	1.888	0.632	263
Management Support			
Alpha: .8896			
AS4	1.977	0.635	261
AS5	1.897	0.660	261
AS6	1.776	0.673	261
AS7	1.686	0.779	261
AS8	1.879	0.668	261
AS9	1.831	0.602	223
Formal Goals			
OP11	3.093	1.397	226
AS11	0.686	0.465	226

Integration			
Data Quality			
Alpha: .9102			
	MEAN	STD	Cases
IN1	1.507	1.406	259
IN2	1.808	1.117	259
IN3	1.310	1.469	259
IN4	1.610	1.287	259
Flexibility			
Alpha: .8581			
IN5	0.859	1.544	262
IN7	0.824	1.501	262
Scope			
Alpha: .7381			
IN6	1.593	1.265	263
IN8	1.293	1.439	263

Optimization			
Business Strategy			
Alpha: .7912			
	MEAN	STD	Cases
OP1	1.682	0.697	250
OP2	1.034	0.725	250
OP3	1.908	0.678	250
OP4	2.224	0.539	250
OP6	1.718	0.748	250
Network - 1 item			
OP12	2.095	0.62	263

Training Competence			
Alpha: .7061			
	MEAN	STD	Cases
OP5	1.831	0.585	258
OP7	1.930	0.545	258
AS10	2.027	0.564	258

Cross Validation

Because only 264 surveys were returned, an independent cross validation could not be performed. This would mean having 132 in each sample and this is below the minimum recommended sample size of 200. In addition, a case to parameter ratio below 5 to 1 makes the statistical stability of the estimates become unstable (Kline, 1998).

Sample Characteristics

Industry Sectors

Table 12 shows the industry classification of the respondents. The majority of the respondents, 63.3% were from the manufacturing sector.

TABLE 12. Industry Classification for Dissertation Study

Industry	Frequency	Percent
Banking and Finance	8	3.0
Manufacturing	167	63.3
Retail	14	5.3
Service	35	13.3
Transportation	14	5.3
Utilities	11	4.2
Other	13	4.9
Missing	2	.8
Total	264	100.0

The respondents identified their position in the company, of which 48% were Information Technology (IT) Managers, 42% were Chief Executive Officers (CEO) and 4 % were Software Development Managers.

Seniority

Table 13 shows the seniority of the respondents based on the number of years in their current position. Of the IS executives 36% have held their position for less than 5 years, 16% have held their position for 6-10 years, and 12 % have held their position for more than 11 years.

TABLE 13. Frequency for the Variable: Years in Current Job

		Frequency	Percent	Valid	Cumulative Percent
Valid	0-5	95	36.0	56.5	56.5
	6-10	41	15.5	24.4	81.0
	11-15	19	7.2	11.3	92.3
	16-20	3	1.1	1.8	94.0
	21+	10	3.8	6.0	100.0
	Total	168	63.6	100.0	
Missing	System	96	36.4		
Total		264	100.0		

Dependent (Endogenous) Variable

The dependent variable, performance, was measured by a satisfaction rating in which the executive was asked to determine a general "satisfaction rating of the ERP project". The six options were: "Not Satisfied; Minimal; Moderate; Fair; Above Average; Superior". The six-point scale is preferable to an odd number scale because respondents can not pick a mid-point and they will have to choose towards one side. The satisfaction rating is a direct measure of a project's performance as perceived by the top level IS executives surveyed in the study. The frequency ratings from the responses gathered in the study are presented in Table 14.

TABLE 14. Frequency of Performance Ratings

		Frequency	Percent	Valid	Cumulative Percent
Valid	0	2	.8	.8	.8
	1	10	3.8	3.9	4.7
	2	35	13.3	13.8	18.5
	3	70	26.5	27.6	46.1
	4	117	44.3	46.1	92.1
	5	20	7.6	7.9	100.0
	Total	254	96.2	100.0	
Missing	System	10	3.8		
Total		264	100.0		

The scale was coded using the following system: Not Satisfied=0; Minimal=1; Moderate=2; Fair=3; Above Average=4; Superior=5. The mean for the dissertation study is 3.38 and the standard deviation is 1.00.

Statistical Analysis

Exploratory Factor Analysis

Exploratory factor analysis was performed on the data because the pilot study instrument was changed and because the sample size for the pilot study was too small. The analysis done in the pilot study was done under the consideration that there were only 26 responses and differences were to be expected in the full study with 264 responses. The purpose for the exploratory factor analysis is to reduce the number of variables. Using the anti-image correlation matrix, the measure of sampling adequacy (MSA) was computed to quantify the degree of intercorrelations within the constructs. In the absorptive capacity construct there were two variables falling below the .6 range, i.e. in the miserable category (Hair et al., 1998). The two questions were, "The underlying skills associated with the IS function are rapidly changing (.579)" and "The optimal configuration of hardware/software required to perform ERP is rapidly changing (.530)." These two questions were, therefore, eliminated from the model. The elimination of these variables does not create a theoretical imbalance because there are still other questions that measure change readiness. All other variables, including those in the assimilation, integration and optimization constructs had an MSA above .70 (middling). Most scores were above .80 and were considered meritorious. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Barlett's Test of Sphericity for the constructs indicated there were sufficient intercorrelations within the constructs.

The exploratory factor analysis test done on the data confirmed the possibility of having four factors or dimensions that represented absorptive capacity as was suggested with the pilot study data. Examining the entire correlation matrix to determine the appropriateness of factor analysis, the Bartlett's test of sphericity showed that nonzero correlations exist at the significance level of .0000 and the Kaiser-Meyer-Olkin measure of significance adequacy of .863 is in the high range of adequacy, as shown in Table 15. The sample to variable ratio of 17.6 to 1 is good because the chance of overfitting the data is minimized and the generalizability of the results is maximized. The total variance explained with the four factors was 55.79% as shown in Table 16. The total variance explained percentage obtained for this factor analysis was above the .50 mark suggested by Hair et al. (1998). The rotated (varimax) item loadings are presented in Table 17. A varimax rotation was chosen because the ultimate goal for using factor analysis in this study was to reduce the number of variables into a smaller set of uncorrelated variables for subsequent use in a structural equation model. Oblique rotations were performed on the dataset and are included in Appendix C. The oblique rotation revealed very similar item loadings on the factors and all produced four factors. The varimax rotation was the rotation with the cleanest loadings with fewer items loading significantly in more than one factor.

TABLE 15. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.863
Bartlett's Test of Sphericity	Approx. Chi-Square	1100.962
	df	105
	Sig.	.000

TABLE 16. Total Variance Explained

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	5.00	33.38	33.38
2	1.27	8.51	41.89
3	1.06	7.09	48.99
4	1.02	6.79	55.79

TABLE 17. Rotated Component Matrix

	Competence	Org Culture	Motivation Mechanisms	Change Readiness
There is a vision of what is trying to be		.53		
Users have been given information of state-of-the-art technology		.69		
There is a clear division of roles and responsibilities to implement ERP		.59		
The project team is composed of people from diverse areas of expertise		.64		
Departments are cooperating in the ERP implentation effort		.50		
Users have a common understanding of the technical language used by the project team	.55			
The necessary skills to implement ERP exist	.68			
There is technological competence to absorb ERP	.83			
There is managerial competence to absorb ERP	.79			
The ERP project team has good relationships with outside experts in ERP		.59	.44	
The organizational structure in this firm is best characterized as formal			.67	
The firm's compensation policies provide motivation for the adoption of ERP			.72	
It is well known who can exploit new information provided through ERP	.44			.52
It is well known who can help solve problems in ERP implementation				.50
R&D efforts are being conducted in ERP technology				-.64

Extraction Method: Principal Component
Rotation Method: Varimax with Kaiser

- For clarity, only loadings above .43 are shown.
- Values above .35 are considered significant at a .05 level (power of 80%) for the sample size of 264 (Hair, 1998)

The four-factor solution presented in Table 17 includes the factors: competence, organizational culture, motivation mechanisms and change readiness. Organizational culture includes questions about vision, state of the art technology, division of roles and responsibilities and departmental cooperation. The second factor is named competence and is comprised of the questions about the project team having a common technical understanding and if the firm as a whole had the necessary skills and technological and managerial competence to absorb ERP. The third factor, motivation mechanisms, is composed of questions regarding organizational formality, compensation policies, and relationship with outside experts. Questions loading into the fourth factor ask about who can exploit the new information, who can help solve problems and R& D efforts, therefore this factor is named change readiness.

Confirmatory Factor Analysis

SEM provides a confirmatory factor analysis, a confirmation test of the scales already provided in the literature and a measure of internal consistency reliability of each construct assessed. Figure 8 shows the measurement model for absorptive capacity and Figure 9 shows the confirmatory factor analysis done for the second order absorptive capacity model. The path coefficients show the correlations between the constructs. It can be seen that the constructs are highly correlated. Organizational culture and change readiness, for example show a .81 correlation loading. Further analysis considering the individual item loadings on each construct show that there are three very low loadings to the constructs, the lowest of which is .15 for item AC13 on change readiness.

FIGURE 8. Measurement Model for Absorptive Capacity

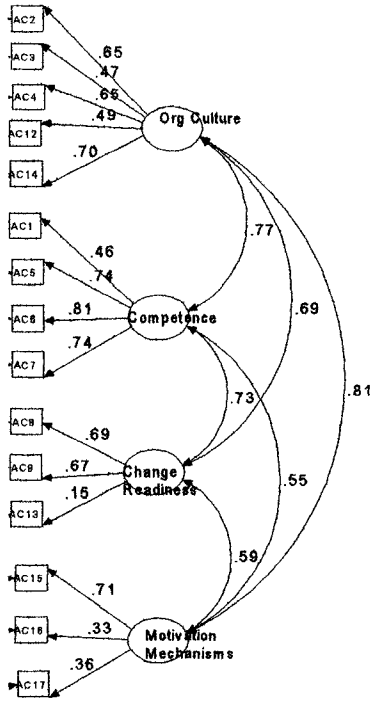
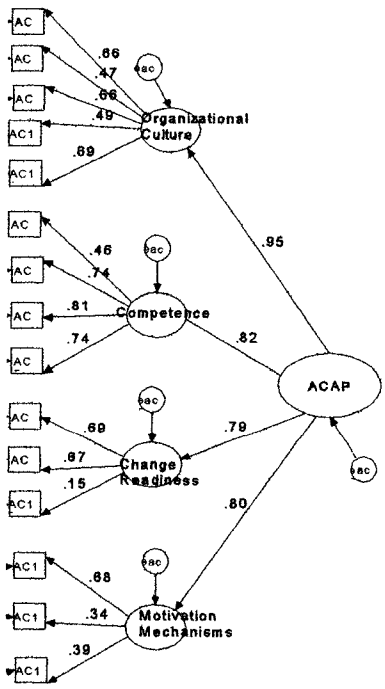


FIGURE 9. Second-Order Model for Absorptive Capacity



The goodness of fit measures for the measurement model are shown in Table 18. The model has good absolute fit measures with a normed fit index (NFI) of .94 and a relative fit index (RFI) of .92. A score of 1 for the indices indicate a perfect fit and these scores are quite high. The root mean square error approximation (RMSEA) of .06 is within the .05 to .08 range deemed acceptable (Hair et al., 1998). The measurement model's incremental fit measures are .96 and .97 and therefore also very good. The parsimony fit measures are not good, however, as they fall well below the .90 recommended level (Hair et al., 1998). The parsimony fit measures are comparable to the adjusted r-squared values in regression, where the number of coefficients is considered. The normed-chi-square is within the recommended level. In general, the various measures of overall goodness of fit indicate that the measurement model is acceptable.

TABLE 18. Goodness of Fit for The Absorptive Capacity Model

Goodness-of Fit Measure	Measurement Model
Absolute Fit Measures	
Likelihood-ratio chi-square (x^2)	168.85
Degrees of freedom	84
Noncentrality Parameter (NCP)	84.85
Normed fit index (NFI)	.94
Relative fit index (RFI)	.92
Root mean square error of approximation (RMSEA)	.06
Expected cross-validation index (ECVI)	1.03
Incremental Fit Measures	
Incremental fit index (IFI)	.97
Tucker-Lewis index (TLI) or (NNFI)	.96
Comparative fit index (CFI)	.97
Parsimonious Fit Measures	
Parsimonious fit index (PNFI)	.70
Parsimony adjusted CFI (PCFI)	.68
Normed chi-square	2.01
Akaike information criterion	270.85

The practical significance of the model is a contribution because it provides empirical support for the dimensions of absorptive capacity mentioned in the literature. Organizational culture (Boyton et al., 1994; Cohen & Levinthal, 1990; Hoffman & Klepper, 2000; Lyles & Salk, 1996; Renko et al ,2001; Stasser el al., 1995; Van den Bosch et al, 1999; Watson et al, 1993), competence (Compeau & Higgins, 1995; Marakas et al. 1998), motivation mechanisms (Bandura, 1977; Compeau & Higgins, 1995; Marakas et al., 1998; Shaw et al., 2001) and change readiness (Brown & Eisenhardt, 1997; Orlikowski & Hoffman, 1977;) are supported as dimensions of absorptive capacity in this study.

The other constructs in the study, assimilation, integration and optimization, were also analyzed through confirmatory factor analysis. Figure 10 portrays the measurement model for assimilation. The three subscales in assimilation are management support, flexibility and adaptability of the firm, scope of the ERP project and formal goals. Figure 11 shows the measurement model for integration; its variables are flexibility of the IT technology and data quality. The model's fit improved considerably when the variable flexibility and scope was divided in two. The measurement model for optimization is shown in Figure 12 and its three variables are training competence, business strategy and network. Table 19 shows the fit measurements for the three constructs. The absolute and incremental fit measures for the constructs are considered good for all three constructs because the NFI, RFI, IFI, TLI and CFI indices are well above .90. The RMSEA for assimilation is slightly above the .10 recommended level. According to Joreskog (1970) a normed chi-square ratio of 5 is acceptable, especially when taking the high values of the

other indices into consideration. Therefore, the models for the constructs were considered adequate.

FIGURE 10. Measurement Model For Assimilation

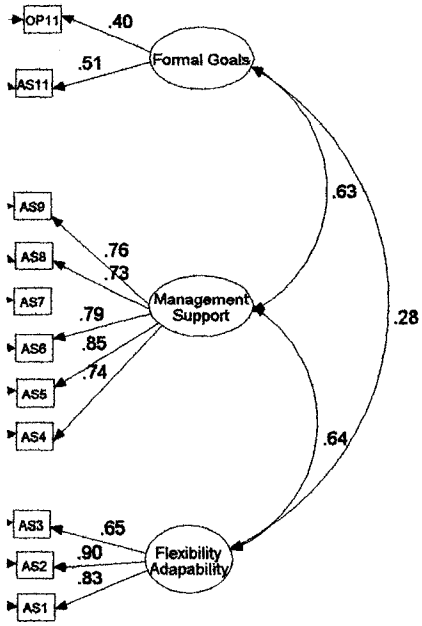


FIGURE 11. Measurement Model For Integration

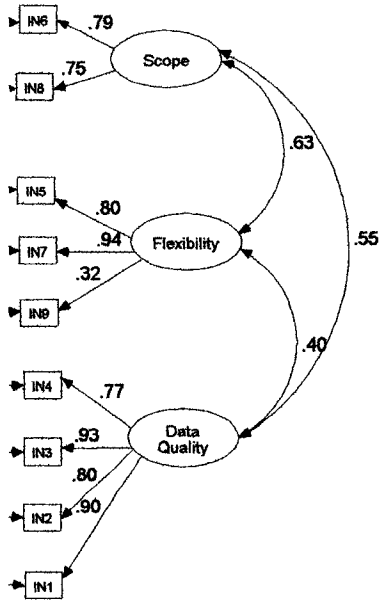


FIGURE 12. Measurement Model For Optimization

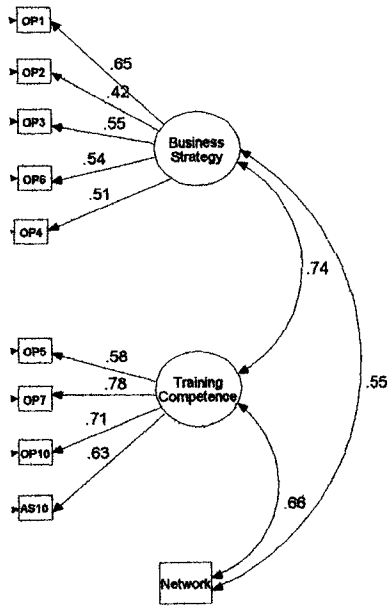


TABLE 19. Goodness of Fit Measures for Assimilation, Integration and Optimization

Goodness-of Fit Measure	Assimilation	Integration	Optimization
Absolute Fit Measures			
Likelihood-ratio chi-square (x^2)	250.74	81.06	122.24
Degrees of freedom	42	24	32
Noncentrality Parameter (NCP)	221.69	41.65	89.24
Normed fit index (NFI)	.97	.97	.98
Relative fit index (RFI)	.95	.95	.97
Root mean square error of approximation (RMSEA)	.14	.10	.10
Expected cross-validation index (ECVI)	1.22	.48	.71
Incremental Fit Measures			
Incremental fit index (IFI)	.97	.98	.99
Tucker-Lewis index (TLI) or (NNFI)	.96	.96	.98
Comparative fit index (CFI)	.97	.98	.99
Parsimonious Fit Measures			
Parsimonious fit index (PNFI)	.61	.52	.59
Parsimony adjusted CFI (PCFI)	.62	.52	.59
Normed chi-square	5.97	3.38	3.70
Akaike information criterion	320.74	141.06	186.24

Table 20 shows the standardized regression weights of each of the second-order constructs. Each construct was evaluated separately by assessing the construct's reliability and variance extracted using the following formulas:

$$\text{Construct Reliability} = \frac{(\Sigma \text{ standardized loading})^2}{(\Sigma \text{ standardized loading})^2 + \Sigma \text{ indicator measurement error}}$$

$$\text{Variance Extracted} = \frac{\Sigma (\text{standardized loading}^2)}{\Sigma (\text{standardized loading}^2) + \Sigma \text{ indicator measurement error}}$$

Computations for each measurement are shown in Table17. The four constructs exceed the recommended level of .70. For the variance-extracted measures, the four constructs are above the 50% recommended extracted variance.

TABLE 20. Second-Order Construct Regression Weights, Reliability and Variance Extracted

Construct	Standardized Regression Weights	Reliability	Variance Extracted
Absorptive Capacity		.89	.68
Organizational Culture	.94		
Competence	.79		
Motivation Mechanisms	.71		
Change Readiness	.84		
Assimilation		.82	.61
Management Support	.85		
Flexibility and Adaptability	.71		
Formal Goals	.78		
Integration		.78	.54
Scope	.76		
Data Quality	.64		
Flexibility of IT project	.80		
Optimization		.84	.65
Business Strategy	.75		
Training Competence	.97		
Network	.69		

The correlations between the summated constructs and performance were examined and are shown in Table 21. SEM results can be affected by multicollinearity and therefore correlations above .80 are generally regarded as problematic (Hair et al., 1998). In this study all correlations fall below this range.

TABLE 21. Correlations

		ACAP	Assimilation	Integration	Optimization	Performance
ACAP	Pearson Correlation	1.000	.668**	.444**	.549**	.494**
	Sig. (2-tailed)	.	.000	.000	.000	.000
	N	259	219	254	238	249
Assimilation	Pearson Correlation	.668**	1.000	.376**	.672**	.379**
	Sig. (2-tailed)	.000	.	.000	.000	.000
	N	219	223	220	205	216
Integration	Pearson Correlation	.444**	.376**	1.000	.396**	.487**
	Sig. (2-tailed)	.000	.000	.	.000	.000
	N	254	220	259	239	249
Optimization	Pearson Correlation	.549**	.672**	.396**	1.000	.353**
	Sig. (2-tailed)	.000	.000	.000	.	.000
	N	238	205	239	243	236
Performance	Pearson Correlation	.494**	.379**	.487**	.353**	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	.
	N	249	216	249	236	254

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

Structural Equation Model

One important step before performing a multivariate analysis is to examine the underlying assumptions of the technique. Structural equation modeling (SEM) is particularly sensitive to data distribution, as it does not use individual observations but rather uses the correlation and covariance of the data. Normal distribution in the data can be determined by observing its kurtosis or skewness. "A lack of multivariate normality is particularly troublesome because it substantially inflates the chi-square statistic," (Hair et al., 1998, p. 601). The data was examined by checking for normality, and linearity (see Appendix D), and there was no evidence that any of these assumptions were violated.

Another area of concern in examining the data is missing data because missing data can have a profound effect on calculating the input data matrix to be used in the estimation process (Hair et al., 1998). To handle missing data, the computer program used in this study, Analysis of Moment Structures or AMOS, performs maximum likelihood instead of the pairwise deletions, listwise deletions or imputations used in other statistical packages. The setting used for "covariances supplied at input" was unbiased and for "covariances to be analyzed," it was maximum likelihood. The large sample size used in the analysis is also important in that the effect of missing data is considerably reduced. The ratio of parameters to cases exceeds the minimum 5 to 1 proportion that is generally recommended (Hair et al., 1998; Kline, 1998).

Structural Equation Modeling (SEM) was used to test the stipulated relationships in the hypotheses. Figure 13 displays the estimated model diagram used for the analysis, and Figures 14-17 show the individual loadings for the second order factors. The fit indices for the model are presented in Table 22.

FIGURE 13: Estimated Model for Dissertation Study

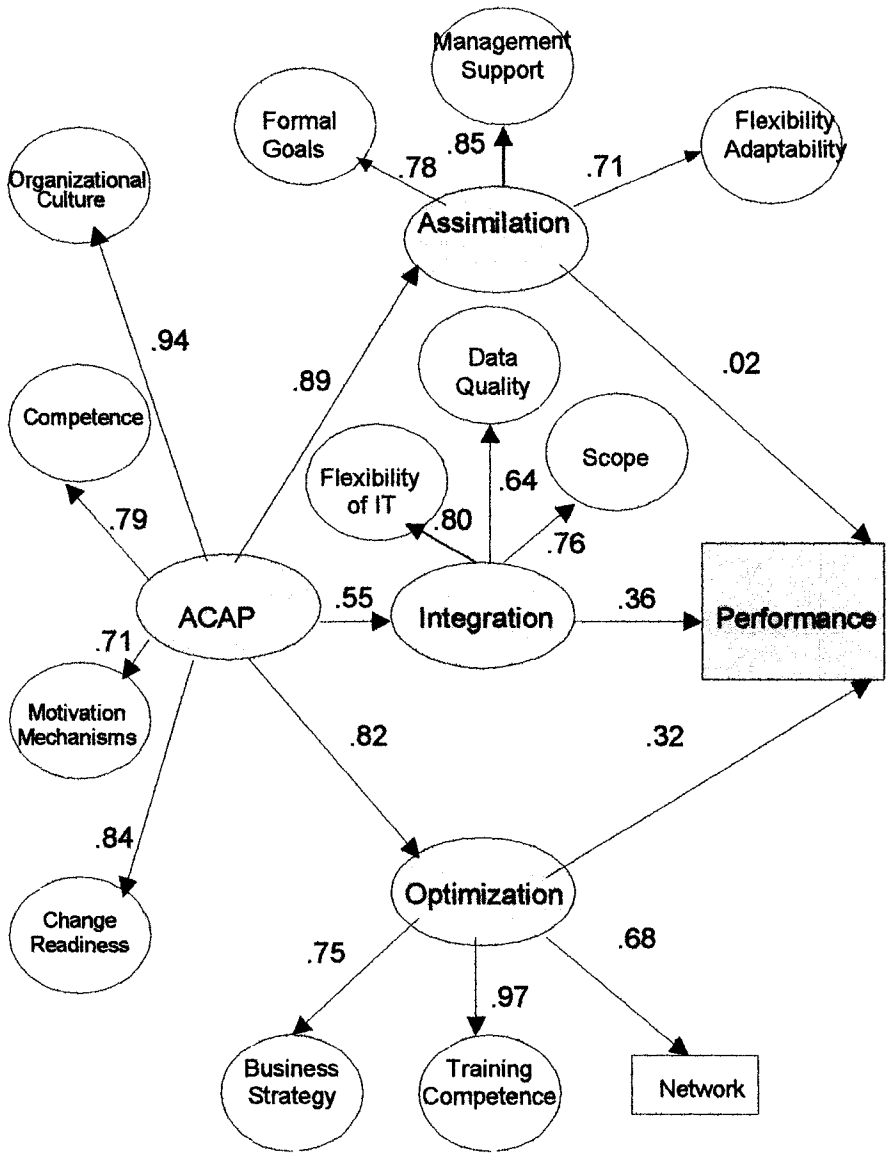


FIGURE 14. Standardized Regression Weights for Assimilation

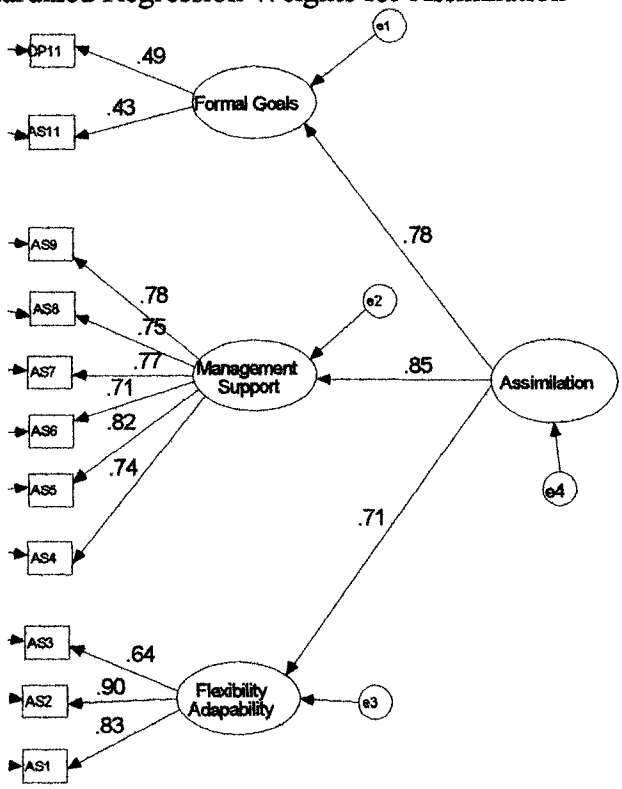


FIGURE 15. Standardized Regression Weights for Integration

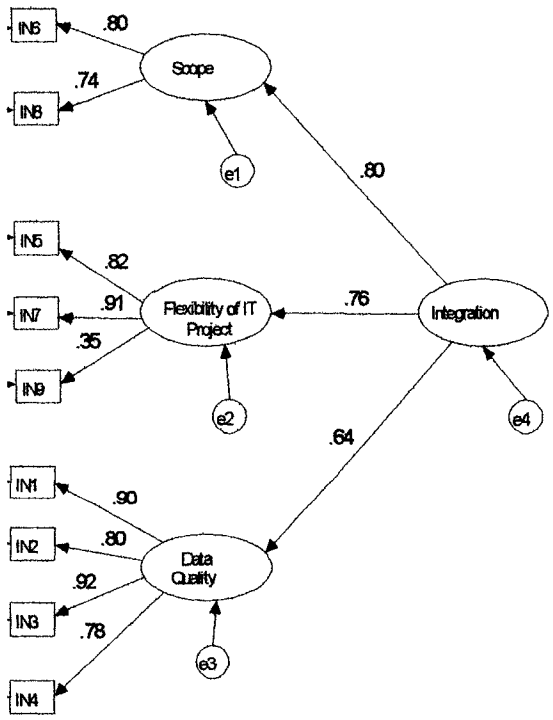


FIGURE 16. Standardized Regression Weights for Optimization

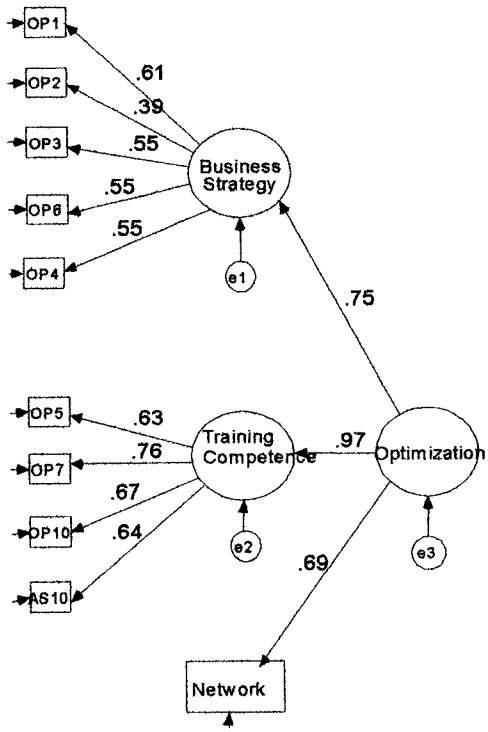


TABLE 22. Goodness-of-Fit Measures for the Estimated Models

Goodness-of Fit Measure	Estimated Model
Absolute Fit Measures	
Likelihood-ratio chi-square (x^2)	1983.48
Degrees of freedom	973
Noncentrality Parameter (NCP)	1010.48
Normed fit index (NFI)	.91
Relative fit index (RFI)	.90
Root mean square error of approximation (RMSEA)	.06
Expected cross-validation index (ECVI)	8.71
Incremental Fit Measures	
Incremental fit index (IFI)	.95
Tucker-Lewis index (TLI) or (NNFI)	.95
Comparative fit index (CFI)	.95
Parsimonious Fit Measures	
Parsimonious fit index (PNFI)	.82
Parsimony adjusted CFI (PCFI)	.86
Normed chi-square	2.04
Akaike information criterion	2291.48

The fit indices for the model all indicate good fit. Chi square/df is 2.04, which is better than the generally accepted ratio of 3 and the more liberal ratio of 5. The Bentler-Bonnet Normed Fit Index (NFI), which indicates the proportion in the improvement of the overall fit of the absorptive capacity model to a null model is .91. The NNFI or Tucker-Lewis index, which is less affected by sample size, is .95. The Standardized Root Mean Squared Residual (SRMR), which is a standardized summary of the average covariance residuals, is .06. SEM literature suggests that the SRMR absolute value should be less than .10. Because numerous fit indices are favorable, the model fit is considered good.

Hypotheses

Table 23 summarizes the analyses that determined the support or lack thereof for the hypotheses presented in Chapter II.

TABLE 23. Summary of Hypotheses Analyses

Hypotheses	Estimated Model
Hypothesis 1: *Absorptive capacity, when mediated by assimilation, does not have a positive impact on performance.*	✔
Hypothesis 2: *Absorptive capacity, when mediated by integration, has a positive impact on performance*	✔
Hypothesis 3: *Absorptive capacity, when mediated by optimization, has a positive impact on performance and with an effect size greater than integration.*	✔
Hypothesis 4: *The total mediating effect of organizational learning between absorptive capacity and performance is above average and positive.*	✔

The analysis begins by examining the direct and indirect effects of absorptive capacity on performance. Table 24 contains the summary of the decomposition analysis for the standardized indirect effects of absorptive capacity on performance when mediated by assimilation, integration and optimization. The indirect effect is calculated by multiplying the two sections of the paths. The first path ACAP → Assimilation → Performance for example is .02 because it is the result of (.89) * (.02). To determine if the path is significant the following formula described in Baron and Kenny (1986) needs to be calculated for $X \rightarrow Y_1 \rightarrow Y_2$.

$$\frac{\text{Product of coefficient loadings of } X \rightarrow Y_1 \text{ (a) and } Y_1 \rightarrow Y_2 \text{ (b)}}{\text{The Standard Error of ab}}$$

The ratio is interpreted as a z-statistic (Kline, 1998). To achieve a .05 two-tail significance the result must be higher than 1.96 and to achieve a .01 level of significance the value must exceed 2.58.

TABLE 24. Decomposition of Standardized Effects for Estimated Model

Exogenous variable	Endogenous variable
Causal variable	Performance
Absorptive Capacity	
Indirect effect via Assimilation	.02
Indirect effect via Integration	.20**
Indirect effect via Optimization	.26*
Total Effects	.48**

*p<.05; ** p <.01

Standardized path coefficients with values less than .10 show a small effect; values in the .30 range indicate a medium effect while values larger than .50 suggest a large effect (Kline, 1998). As Table 21 indicates, absorptive capacity is non-significant (.02) when mediated by assimilation, and because absorptive capacity has no indirect effect on performance when mediated by assimilation, Hypothesis 1 is supported. The indirect effect of absorptive capacity on performance when mediated by integration is .20 and, because the path is significant, Hypothesis 2 is also supported. The mediating effect of optimization between absorptive capacity and performance is positive (.26) and significant and the effect size is greater than the effect size for integration; therefore, there is support for Hypothesis 3. The total effect of absorptive capacity on performance

(.48) is considered in the large range and is statistically significant. To show the significance of the total indirect effect of absorptive capacity, it is necessary to run a regression with performance as the dependent variable and ACAP as the independent variable (Kline, 1998). The results of this the regression analysis were significant, therefore, there is support for Hypothesis 4. The r-squared for the regression used to determine the significance of the total effects where the summated absorptive capacity construct is used as the predictor for the rating of the ERP project is .244.

In summary, this chapter has presented the results of the dissertation study, which met with a response rate of 9.5%. Confirmatory factor analysis and structural equation modeling was used as proposed in Chapter III. The fit measurements of the estimated model were all superb, indicating high reliability in the scales. An analysis of the hypotheses with the estimated model provided support for the first hypothesis, which stated that there would be a non-positive indirect effect of absorptive capacity towards performance when mediated by assimilation. The second hypothesis proposed that the path, ACAP-integration-performance would be significant, but the effect size would be less than that of optimization, and support was found for Hypothesis 2. The third hypothesis was not rejected because there was support to indicate that optimization would significantly and positively mediate absorptive capacity and performance and the effect size would be greater than that of the mediation effect of integration. The fourth hypothesis was also accepted because the total medium effect of organizational learning between ACAP and performance is in the large range. All four factors load highly but can be given a ranking from high to low: organizational culture, motivation mechanisms,

competence and change readiness. The practical implications of the findings, discussion and conclusions of these research results are presented in Chapter V.

CHAPTER V

DISCUSSION AND CONCLUSION

Following the presentation of the findings in Chapter IV, this chapter discusses the implications of the findings. By taking notice of the limitations of this dissertation study, ideas for extension and improvement become evident. The chapter will suggest several avenues for future research and end with concluding remarks.

Discussion

The two major questions raised in this dissertation are 1) What organizational processes contribute to the successful implementation of IS? and 2) Why do some organizations achieve financial returns and strategic advantages from IS efforts while others do not? Analysis of the results of this research suggests that the basic answer to both questions is path dependence. The results emphasize the prominent role of absorptive capacity in organizational learning and performance and it highlights the different ways in which absorptive capacity influences each component of organizational learning. This dissertation proposed and tested a model of absorptive capacity in the context of IT adoption, specifically ERP projects. While prior research focused on understanding, assimilating and commercially applying external knowledge (Lane et al. 1998), this model provides a path analysis joining the literature on organizational

learning and absorptive capacity. Absorptive capacity reflects the potential to increase performance, but does not necessarily guarantee the successful exploitation of the new knowledge (Zahra & George, 2000). Therefore, absorptive capacity is placed as an antecedent to organizational learning that mediates the relationship between absorptive capacity and performance.

Through exploratory and confirmatory factor analysis four dimensions of absorptive capacity have been identified. These dimensions are organizational culture, competence (managerial and technical), motivation mechanisms and change readiness. The factor with the highest regression weight is organizational culture. Organizational culture is composed of several key items such as departmental cooperation, having a vision of what the IS project will achieve, clear division of roles and responsibilities, diversity of project team members and keeping informed of state-of-the-art technology. Another variable within ACAP (absorptive capacity) is competence and it includes technical competence, and managerial competence to absorb ERP. The third component is change readiness, which requires knowing who can exploit information, who can solve problems and R&D efforts. The fourth dimension is motivation mechanisms; it is composed of three items including having a relationship with outside experts, having compensation policies that provide motivation for the adoption of the IS project and the formality of an organizational structure. The sorting of these findings reveal the relative value of developing each of the elements as firms invest in improving their absorptive capacity. Interestingly, research and development, a frequent proxy for absorptive capacity commonly used in this field of study, has a low ranking within its variable. This means that though research and development plays a role in absorptive capacity, its role

explains only a fraction of the absorptive capacity construct and should not be taken as a proxy. Another interesting finding is that compensation policies do not play a strong role in promoting absorptive capacity. The findings coincide with Szulanski's (1996) conclusions, which suggest that using only incentive practices to encourage knowledge transfer or "internal stickiness" is misled (Szulanski, 1996). Managerial attention should focus on fostering closer relationships among organizational units and understanding communication patterns (Szulanski, 1996).

To the extent that a firm invests in improving absorptive capacity, a firm can focus on the elements of absorptive capacity. For example, interorganizational relationships create opportunities for knowledge acquisition and exploitation (Lane & Lubatkin, 1998, Renko et al., 2001). Similarly, through interactions with others, firms get access to external knowledge and combine it with existing knowledge. Enhancing both the depth and breadth of external knowledge, or specialization, is also an important element in absorptive capacity. The right balance between insourcing and outsourcing is crucial because no company is able to develop internally all the necessary technology (Osterloh & Frey, 2000).

The dissertation confirms the mediating effect of organizational learning between absorptive capacity and performance. This study extends previous research on organizational learning by empirically examining the effects of absorptive capacity on performance mediated by organizational learning. Toward this end, organizational learning was divided into three stages to see the individual indirect effect of absorptive capacity when mediated by each stage, assimilation, integration and optimization. The effect of assimilation is insignificant as expected. Measured in assimilation is the effect

of superiors lending support to the project team in the form of managerial resources, time, administrative support, emotional support, training and monitoring progress. The other variables measured in assimilation are having formally articulated goals and the flexibility, adaptability and creativity of the firm. The practical implications of this finding suggests that though assimilation is a part of organizational learning, it is insufficient for success in IS projects.

The second stage in organizational learning is integration. The mediating value of integration stated in Hypothesis 2 was confirmed in the study. This has considerable impact because literature in the management information systems field, as well as the decision sciences field, have focused on measuring integration as a measure of success for an information systems project. There is a strong bias to measure an information system by how much efficiency is improved. From the literature efficiency measured by "accuracy", "comprehensiveness", "correctness", and "consistency" is the justification for the success of an IS project. Yet, studies failed to prove how this improvement in efficiency affects the bottom line of the company. The findings of this study suggest that the mediating effect of integration between absorptive capacity and performance is small. In other words, the quality of the data, the software's flexibility and ability to integrate various functional areas are not adequate evaluative measures for IS-project success.

Optimization, the third stage in organizational learning, in proportion to integration provides a larger intermediary effect between absorptive capacity and performance. The effect size being moderate, it is of more importance than the effect of integration. Optimization's variables include training competence, business strategy and the sharing of information between departments or networking. These are the processes

that make a difference in IS project success measures. Focusing on the effectiveness of user training is critical to the success of IS projects. Are, in fact, user skills improving? Was the user training effective? Has the training created expertise within the firm? In addition to inquiring about training effectiveness, emphasis should focus on what is being done with the information. Has it been integrated to the business strategy of the firm in creating new products, influencing the channels of distribution or customer service? Also important is having highly trained personnel within the IT department.

Confirming the fourth hypothesis in the dissertation, the total mediating effect of organizational learning between absorptive capacity and performance is considered large. Therefore, the path diagram proposed in the research framework is empirically supported in this dissertation. Some organizations achieve financial returns and strategic advantages from their information systems efforts because they progress to the optimization stage of organizational learning and convert their potential absorptive capacity into actual performance gains. This dissertation has found support for the importance of user training, integration of IS into business strategy and networking as key businesses processes in the optimization stage.

Because information technology investment composes about 40% of the total new capital equipment investment in the United States (Hitt & Byrnjolfsson, 1997), the uncertainty of its productivity is startling (Strassman, 1999). Findings have been contradictory and results have not supported a conclusive positive result (Byrnjolfsson & Hitt, 2000; Shu, 2001; Sichel, 1999). Many who have been inspired to investigate whether investment in IT leads to greater productivity have found lack of evidence to support IT productivity, and thus the phrase, "information productivity paradox"

(Yorukoglu, 1998). Many justifications have been raised to explain the lack of empirical proof for IT productivity.

Some of the more compelling arguments used to explain the lack of productivity include: rapid technological improvements force a very rapid pace of investment. An equally rapid pace of organizational adaptation, change, and organizational learning that would maximize the investment's potential benefits does not follow the rapid pace of innovation. This study has found support to the argument that the initial stages of IT adoption, which are assimilation and integration are less productive because of the learning curve involved. Expertise in using a particular technology is built over time. Yorukoglu (1998) found that for the period of 1987-1991, for every additional year of age in IT capital investment, a company's output increased 2%. IT investment costs are concentrated in the first year at an average of 40% of total IT investment, while investment in conventional capital averages only 25% of its total investment in the first year.

Literature in strategy and competitive advantage of the firm have stressed that optimization is the key stage in organizational learning. This is when a firm transforms efficiency into effectiveness. The measures for optimization lie in the effect the information system has had on the users and on the firm and not in the efficiency of the system.

Conclusions

A path model of absorptive capacity was tested for this dissertation and it establishes the significance and magnitude of the total indirect effect of absorptive capacity on performance when mediated by organizational learning. It indicates that the

ACAP-optimization-performance path is the strongest path, followed by the ACAP-integration-performance path. This is inline with what was expected *a priori* to the study because integration has been a very predominant force in the IS literature as has the topic of the fusion of information systems with strategy been an important force in the strategy literature. The combined mediation effect of the three stages of organizational learning found in this dissertation is of major consequence because it provides proof that organizational learning is an important mediator between absorptive capacity and performance. The model supported in this dissertation adds perspective and organization to the variables by dividing organizational learning into three stages. The path diagram indicates a process, a path analysis where the potential, mediated by learning, translates to performance.

Another major contribution of the dissertation is the organization of the construct of absorptive capacity into dimensions such as organizational culture, competence, motivation mechanisms and change readiness. Firms are encouraged to invest in developing their absorptive capacity but this is not an automatic 1 to 1 translation into performance. Firms must be concerned with how well the organization is learning as they assimilate, integrate and, most especially, optimize the technology.

Limitations and Delimitations

There are several limitations and delimitations caused by the design of the study. The study is a cross-sectional and not a longitudinal study. It captures a measurement of the constructs as they are at the time of the survey and not their movement in one way or another in the progression of time. The sample has a large proportion of respondents in the manufacturing sector. Greater effort can be taken to survey other sectors including

banking and finance, retail, transportation, utilities and the service industry. Even though the survey asks for different types of ERP modules were used in the firm that include manufacturing, purchasing, accounting, human resources, customer relations and e-commerce, this information is not used as a control variable. Future research could investigate only certain types or combinations of types of modules. Another aspect is the date of ERP purchase. In this dissertation, the dates of ERP acquisition ranged from 1984 to 2003. There were 8 respondents in the pre-90's range, 26 from 1990-1994, 19 in 1995, 22 in 1996, 30 in 1997, 53 in 1998, 17 in 2000 and 24 adopters in the new millennium. Future research could focus on the date of ERP acquisition as a control variable. Another limitation is that there were not enough responses to perform a test-retest analysis to test the reliability of the model and this is an issue that can be resolved through future research.

Future Research

The findings also suggest other areas of future research. The study was designed to measure performance as perceived by a top level IS executive in regards to an ERP project. Though the high level executive has a bird's eye view of the ERP project and is very qualified to make such an assessment, performance can be measured through different indices. A more detailed analysis can look at return on investment with actual increases in sales and profits. The study could be longitudinal taking the impact in profit margins over an extended period in time.

In addition, other executives within the firm can be surveyed. It will be interesting to see how the VP of Finance, The VP of Marketing, The VP of Operations or Human Resources perceive the performance of the ERP project. Their perceptions would add

wholeness and dimension to the performance variable. Unfortunately, it would be very difficult to obtain all these perspectives. The methodology would need to shift to a field study instead of mailed surveys, thereby compromising the generalizability of the study.

Future analysis can identify ERP vendors to investigate differences in performance according to vendor. In this study there were 55 respondents identified as using SAP, 42 were using Oracle, 27 were using People Soft, 25 were using JD Edwards, 10 had developed home versions. Other vendors worth mentioning that had between 5-10 clients in this study are Mapics, Epicor, Baan and Lawson.

In closing, the results of the study present contribution to the literature in the fields of management information systems, organizational learning, and strategy. The model used in this dissertation provides an intersection of the three fields. Organizational learning is a situated process embedded in its social, cultural and physical setting (Renko et al., 2001; Tyre & von Hippel, 1997;). Other country settings may provide support on the generalizability of the theoretical positions established here. Canada and the US have exhibited similar perceptions that may or may not be similar in other countries. International IS literature, is a relatively new area of study and it would be very beneficial to see if the technology adoption process is universal or subject to cultural influences. Certainly there is a difference in social process and communication styles and so the loadings in the different items composing absorptive capacity and organizational learning are subject to change. This presents an interesting challenge for future research that engages in examining cultural differences in the technology adoption process. Overall, this dissertation suggests that understanding the success of IS projects is a process that requires the blending of existing theories in absorptive capacity, organizational learning

and strategy into a path diagram where organizational learning comprised of assimilation, integration and optimization mediates the relationship between absorptive capacity and performance.

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APPENDIX A

PILOT STUDY COVER LETTER

Edith Galy
305 San Diego Ave.
Brownsville, Tx. 78526

XX Company
XX Address
XX City, State, Zip

October 29, 2002

Dear XXX:

I am Edith Galy, PhD Student in International Business at the University of Texas Pan American in Edinburg, Texas. I would like to ask for your help in research on absorptive capacity in adopting, integrating and exploiting technology. The study will contribute to our understanding of maximizing performance in IT investments. It will examine potential benefits of utilizing advanced information systems for the business community. Your name was selected from the Directory of Top Computer Executives, which indicates that your firm is using Enterprise Resource Planning (ERP).

The enclosed questionnaire collects data to be analyzed as part of my doctoral dissertation research at the University of Texas Pan American. Much of the IT literature has focused on the decision to adopt technology. This research, however, will study the organizational learning stages that follow the implementation of a new technology in the firm. The constructs included in the study are assimilation, integration and exploitation. The term used in the literature to refer to firm readiness to technological advances is absorptive capacity. Absorptive capacity is the firm's ability to perceive value in external information, in this case an information system, and be able to adopt it, internalize it and exploit it to maximize profits. Your cooperation as a top level IT professional in this study will help achieve these objectives.

Please complete the enclosed questionnaire and return it in the enclosed self-addressed envelope. The survey should take less than 30 minutes to complete.

The research methods used in this study are a systematic process of research to obtain information to answer the research questions/hypotheses. Information about individuals will be kept confidential. Names or any identifying information will not be used in any reports of the research. Only group statistics will be included in such reports.

This survey will be part of an initial pilot study. Your responses and comments will be used to refine the questionnaire. I would like to test the clarity and appropriateness of the items and in addition, determine whether the instructions are adequate.

Please respond by Dec 15th, 2002 so that the full-scale study can be sent out by Jan 15, 2003. If you wish to be informed of the results and analysis of the findings please indicate so in the survey. I will be glad to furnish you with an abstract of the results, which will be useful to you in your efforts to maximize the firm's investment in ERP software.

Prof. Jane LeMaster is the chairperson of my dissertation committee and would be glad to answer any questions you may wish to ask her. To contact Prof. LeMaster please e-mail jlemaster@panam.edu or call 956-381-3317. The costs incurred by this study are self-funded.

I would like to stress the high importance of your contribution to the successful completion of this study.

Best regards,

Edith Galy
PhD Candidate
University of Texas Pan American

APPENDIX B

FULL STUDY COVER LETTER

June 6, 2003

Dear <name>,

I am Edith Galy, PhD Candidate in International Business at the University of Texas Pan American and I would like to ask for your help in research on adopting, integrating and exploiting information technology. The study will contribute to our understanding of maximizing performance in IT projects. It will examine benefits of utilizing advanced information systems for the business community. Your name was selected from the Directory of Top Computer Executives, which indicates that your firm is using Enterprise Resource Planning (ERP).

The enclosed questionnaire collects data to be analyzed as part of my doctoral dissertation research at the University of Texas Pan American. It will extend IS literature that focuses technology adoption. This research studies the organizational learning stages that follow the implementation of a new technology in the firm. The constructs included in the study are assimilation, integration and exploitation that are collectively called absorptive capacity. Absorptive capacity is the firm's ability to perceive value in external information, in this case an information system, and be able to adopt it, internalize it and exploit it to maximize profits. Your cooperation as a top level IT professional in this study will help achieve these objectives.

Please complete the enclosed questionnaire and return it in the enclosed self-addressed envelope. The survey should take less than 30 minutes to complete. If you prefer to send the survey electronically, the survey can also be accessed on line at http://ntmain.utb.edu/dissurvey. For security purposes the survey is password protected. In the user name box please type: **survey** and for the password, please type: **2003Summer** (case sensitive).

All information about individuals will be kept confidential. Names or any identifying information will not be used in any reports of the research. Only aggregate statistics will be included. This dissertation study is surveying 3,000 Information Systems executives in the US and Canada. If you wish to be informed of the results and analysis of the findings please indicate so in the survey. I will be glad to furnish you with an abstract of the results, which will be useful to you in your efforts to maximize the firm's investment in ERP software. The costs incurred by this study are self-funded.

Prof. Jane LeMaster is the chairperson of my dissertation committee and would be glad to answer any questions. To contact Prof. LeMaster please e-mail jlemaster@panam.edu or call 956-381-3317 (website http://www.coba.panam.edu/faculty/jlemaster/index.html). Information about The University of Texas-Pan American's Institutional Review Board, which reviews all research related to human subjects is available at http://www.panam.edu/dept/sponpro/Policies/Institutional_Review_Board.html

I would like to emphasize the high importance of your contribution to the successful completion of this study.

Best regards,

Edith Galy
PhD Candidate
University of Texas Pan American

APPENDIX C

FACTOR ANALYSIS TABLES

TABLE 25. Rotated Component Matrices

Rotated Component Matrix[a]

	Component			
	1	2	3	4
AC1		.534		
AC2	.582			
AC3	.675			
AC4	.676			
AC5		.675		
AC6		.835		
AC7		.797		
AC8	.419	.414		-.483
AC9				-.461
AC12	.630			
AC13				.641
AC14	.568			
AC15	.663			
AC16			.562	
AC17			.736	

Extraction Method: Principal Component Analysis.
Rotation Method: Quartimax with Kaiser Normalization.

a. Rotation converged in 10 iterations.

Structure Matrix

	Component			
	1	2	3	4
AC1	.588			
AC2	.546		-.630	
AC3			-.704	
AC4			-.666	
AC5	.759		-.466	
AC6	.869			
AC7	.812			
AC8	.505	-.587	-.424	
AC9	.476	-.558		
AC12			-.659	
AC13		.572		
AC14	.539		-.616	
AC15			-.637	.537
AC16				.601
AC17				.761

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Component Matrix[a]

	Component			
	1	2	3	4
AC1	.509			
AC2	.674			
AC3	.526			
AC4	.655			
AC5	.747			
AC6	.726			
AC7	.676			
AC8	.589			
AC9	.569			
AC12	.492			
AC13		.498		
AC14	.696			
AC15	.585			
AC16		.488		
AC17			.432	.526

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

APPENDIX D

ITEM STATISTICS

TABLE 26. Item Statistics

Statistics

	N							
	Valid	Missing	Mean	Std. Dev.	Skew-ness	Std. Error of Skew-ness	Kurtosis	Std. Error of Kurtosis
Users have a common understanding of the technical language used by the ERP project team	263	1	.31	1.71	-.435	.150	-1.310	.299
There is a vision of what is trying to be achieved with ERP	264	0	1.38	1.40	-1.290	.150	.874	.299
Users have been given information of state-of-the-art technology involving ERP	262	2	.68	1.53	-.681	.150	-.778	.300
There is a clear division of roles and responsibilities to implement ERP	264	0	1.34	1.47	-1.053	.150	.123	.299
The necessary skills to implement ERP exist	264	0	1.09	1.60	-.986	.150	-.167	.299
There is technological competence to absorb ERP	264	0	1.30	1.38	-1.048	.150	.253	.299
There is managerial competence to absorb ERP	264	0	1.11	1.42	-1.050	.150	.357	.299
It is well known who can exploit new information provided through ERP	264	0	.48	1.47	-.403	.150	-1.000	.299
It is well known who can help solve problems in ERP implementation	263	1	1.40	1.33	-1.209	.150	.783	.299
The underlying skills associated with the IS function are rapidly changing	264	0	1.75	1.35	-1.564	.150	2.008	.299
The optimal configuration of hardware/software required to perform ERP is rapidly changing	264	0	1.23	1.51	-.922	.150	-.068	.299
The project team is composed of people from diverse areas of expertise	264	0	2.03	.97	-1.769	.150	4.662	.299
R&D efforts are being conducted in ERP technology	263	1	.06	1.77	-.212	.150	-1.318	.299
Departments are cooperating in the ERP implentation effort	264	0	1.24	1.35	-1.129	.150	.677	.299
The ERP project team has good relationships with outside experts in ERP	264	0	1.33	1.30	-1.486	.150	2.032	.299
The organizational structure in this firm is best characterized as formal	264	0	.38	1.78	-.363	.150	-1.180	.299
The firm's compensation policies provide motivation for the adoption of ERP	264	0	-.90	1.67	.614	.150	-.752	.299

Statistics

	N							
	Valid	Missing	Mean	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis
IN1	263	1	1.52	1.40	-1.303	.150	1.180	.299
IN2	263	1	1.82	1.12	-1.584	.150	3.125	.299
IN3	263	1	1.32	1.46	-1.136	.150	.707	.299
IN4	262	2	1.61	1.28	-1.342	.150	1.614	.300
IN5	262	2	.86	1.54	-.883	.150	-.229	.300
IN6	263	1	1.59	1.27	-1.453	.150	2.111	.299
IN7	263	1	.83	1.50	-.847	.150	-.295	.299
IN8	263	1	1.29	1.44	-1.268	.150	1.158	.299
IN9	262	2	1.20	1.51	-1.143	.150	.471	.300
AS1	263	1	1.880	.588	-.491	.150	.659	.299
AS2	263	1	1.926	.589	-.303	.150	.145	.299
AS3	263	1	1.886	.632	-.352	.150	.017	.299
AS4	263	1	1.975	.633	-.395	.150	.026	.299
AS5	262	2	1.897	.659	-.466	.150	.435	.300
AS6	263	1	1.778	.672	-.432	.150	.139	.299
AS7	262	2	1.687	.778	-.419	.150	-.157	.300
AS8	263	1	1.878	.666	-.435	.150	.030	.299
AS9	263	1	1.833	.601	-.262	.150	.273	.299
AS10	262	2	2.031	.565	-.635	.150	.896	.300
OP12	263	1	2.095	.620	-.791	.150	1.112	.299
OP1	263	1	1.656	.719	-.381	.150	.075	.299
OP2	254	10	1.018	.731	.015	.153	-.775	.304
OP3	260	4	1.885	.688	-.286	.151	-.107	.301
OP4	263	1	2.217	.536	-1.027	.150	2.184	.299
OP5	260	4	1.821	.596	-1.004	.151	1.446	.301
OP6	253	11	1.723	.748	-.508	.153	.108	.305
OP7	262	2	1.933	.545	-.625	.150	1.162	.300
OP8	262	2	1.927	.518	-.371	.150	.619	.300
OP9	262	2	1.805	.557	-.758	.150	1.414	.300
OP10	257	7	1.788	.702	-.784	.152	.716	.303
OP11	232	32	3.10	1.38	-.217	.160	-.760	.318
AS11	255	9	.69	.46	-.828	.153	-1.326	.304

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EDUCATION

UNIVERSITY OF TEXAS-PAN AMERICAN Edinburg, TX, Fall 1998 – Dec 2003. PhD in International Business with emphasis in Management

UNIVERSITY OF TEXAS at BROWNSVILLE, Brownsville, TX,
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ST. MARY'S UNIVERSITY- San Antonio, TX, Fall 1981-Spring 1984. Graduated Magna Cum Laude, Major: Computer Science and Applied Statistics, Minor: General Business

ACADEMIC AWARDS & HONORS

KPMG Doctoral Scholarship
Fellowship from Thunderbird, The American Graduate School of International Management, Glendale, AZ.
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AREAS OF TEACHING INTEREST

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Management
Strategy

AREAS OF RESEARCH INTEREST

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Employee Motivation/Job Satisfaction/ Turnover