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The Performance Effects of Latent Factors on Assimilation of Commercial Open-Source ERP Software on Small-Medium Enterprises

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THE PERFORMANCE EFFECTS OF LATENT FACTORS ON ASSIMILATION OF COMMERCIAL OPEN-SOURCE ERP SOFTWARE ON SMALL-MEDIUM ENTERPRISES

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Business at Virginia Commonwealth University

by

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ABSTRACT

The Performance Effects of Latent Factors on Assimilation of Commercial Open-Source ERP Software on Small-Medium Enterprises

By Sandra J. Cereola, PhD

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Business at Virginia Commonwealth University.

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This study tests a theoretical model developed to investigate the impact of assimilation of commercial open source enterprise resource planning software (COSES) in small and medium sized enterprises (SMEs). Specifically, the model explains how the top management team's (TMT's) information technology (IT) knowledge and experience impact both assimilation and firm performance. The hypotheses were tested using survey data from SMEs that have implemented COSES. Results from structural equation modeling suggest that SMEs benefit, through higher levels of assimilation and performance, from adopting innovative enterprise resource planning (ERP) systems such as COSES when they have a TMT that has experience with and is knowledgeable about technology. The study also highlights the importance of the TMT in facilitating IT assimilation.

Chapter 1

Introduction

Study Overview

Enterprise resource planning (ERP) systems, when successfully assimilated into a firm, can provide both operational and strategic benefits. The information technology (IT) knowledge and experience of the top management team (TMT) has been shown to have a significant influence on a firm's ability to assimilate IT. This is particularly true for small and medium sized enterprises (SMEs) who do not have extensive IT departments. Traditionally, only large firms have been able to enjoy the benefits of ERP systems. Today, with the drastically changed format of ERP software such as commercial open-source ERP software (COSES), SMEs are now able to benefit from such systems. Applying the resource based view (RBV) of the firm; this study examines a firm's TMT's IT knowledge and IT experience in relation to ERP assimilation and firm performance for SMEs adopting COSES.

Enterprise Resource Planning

Enterprise resource planning systems (ERPs) have evolved slowly over the past forty years. Their roots began in the 1960's with manufacturing systems that focused on inventory control. In the 1970's these systems shifted toward material requirement planning (MRP) which focused on both production planning and inventory control. In the 1980's, the concentration moved toward effective planning and control of *all* manufacturing resources and these systems came to be known as MRPII. Finally, in the 1990's, there was a push to make MRPII an *information technology solution* which

involved creating an integrated system that combined all business functions. These integrated systems became the foundation for the development of enterprise resource planning systems.

ERPs, as developed, were considered an "enterprise wide solution" and were designed to streamline data flow between all functional areas in an organization (Jacobs and Weston 2007). Today's typical ERP systems consist of integrated business modules including marketing and sales, production and inventory control, procurement and distribution, supply chain management (SCM), customer relations management (CRM), human resources management (HRM), finance and accounting, electronic data interchange (EDI), and e-business.

Prior to the development of comprehensive ERPs, business functions of an organization usually consisted of stand-alone legacy systems that were incapable of communicating with each other. ERP systems addressed this problem through the integration of all business processes using a process-view of the firm. A key component of this process-view is its use of a central database which reduced data redundancy, increased data consistency and integrity, and permitted sharing of common data across all business functions in a real-time environment. Largely, ERP systems promised significant benefits, and firms adopted them with the goal of replacing inefficient stand-alone legacy systems, increasing communications between business functions, increasing information processing efficiencies, improving customer relations, and improving overall decision making.

From the onset, large commercial software vendors dominated the ERP market. These vendors included SAP, BaaN, Oracle, PeopleSoft, Navision, and J.D. Edwards. Significant resources were invested by these software firms to develop a "best practices" [1] ERP software solution. The resulting proprietary ERP software packages were grounded in standardized (i.e., generic) business process solutions, they were costly to adopt, required significant time to implement, and often necessitated significant organizational change. Implementation of these ERP systems required organizations to undergo significant business process reengineering (BPR)[2] in order to make their processes "fit" the packaged software.

Due to the tremendous cost, large corporations with the required resources were the first to implement ERP systems. Small and medium sized enterprises (SMEs) lacked the financial, technical, and human resources needed to justify their use. Instead, these smaller organizations purchased stand-alone legacy systems and then, as the company grew, migrated to expensive ERP solutions.

Small and Medium Sized Enterprises (SMEs)

In the late 1990's ERP vendors shifted their interest to the SME market. Their interest primarily stemmed from the saturation of the large enterprise market, the increasingly large number of SME firms, and the introduction of cheaper, more innovative ERP solutions. This shift has resulted in more SMEs adopting or expecting

[1] "Best practices" is a management idea which asserts that there are certain processes that are more efficient or effective at performing a task than any other and these processes have been proven over time (Markus and Tanis 2000).

[2] Business Process Reengineering (BPR) is the fundamental rethinking and radical redesign of support processes to bring about dramatic improvements in performance (Hammer and Champy 1993).

to adopt ERP systems. Based on AMI's 2006-2007 U.S. Small and Medium Business end-user survey, ERP is increasingly becoming a mainstream application for U.S. medium-sized businesses. Over one-third of the respondents indicated that they are currently using ERPs and just over one-quarter indicated they are planning to deploy ERPs in 2007-2008 (AMI 2007).

The introduction of ERP systems to SMEs poses many challenges to ERP vendors as the needs, operating requirements, and financial resources of these firms can differ significantly from large enterprises (Huin 2004). For both large and small enterprises, the decision to acquire an ERP system will have a tremendous impact on the organization as it is a long-term commitment resulting in a considerable financial investment. The risks associated with adopting ERP systems are likely to be greater for SMEs as it represents a larger financial and resource commitment for them than for larger enterprises. In addition, SMEs have less of a chance of recovering from a failed ERP implementation attempt than large enterprises (Muscatello, Small, and Chen 2003).

Although the significance of SMEs is difficult to measure, SMEs play an enormous role in most economies. SMEs are considered the mainstay of most economies particularly in terms of job creation, economic growth, and innovation. According to the US Census Bureau, in 2005 SMEs represented approximately eighty six percent of the total establishments (ninety nine percent of the total firms) and accounted for approximately fifty percent of the total employment (U.S. Census Bureau 2005). In relation to the ERP market, several survey companies have reported that the

overall demand for ERP systems is growing and that a substantial amount of this growth is expected to come from the SME sector (AMI 2007; Aberdeen 2004; AMR 2005).

Based on the large number of SMEs, their increasing interest in ERP systems and their impact on the U.S. economy, there is a need to better understand the ways in which SMEs adopt, implement, and assimilate these systems. Given the projected increase in adoption of ERP systems it is imperative to understand the determinants that can facilitate the successful implementation and assimilation of this technology into firms' daily operations. This is particularly true for SMEs as the format for these ERP systems has drastically changed and the cost of implementing them is no longer prohibitive. Notwithstanding the prolificacy of published ERP research studies using large enterprises, few studies have analyzed its impact on the SME market.

Information Technology Knowledge and Experience of Top Management Team and Resource Based View of the Firm

The TMT of a firm plays a crucial role in the adoption, implementation, and assimilation of IT investments particularly with the adoption of sophisticated technology such as ERP systems. Extant research suggests that a TMT that has the sufficient IT knowledge and experience will be more likely to evaluate the appropriateness of these systems (Armstrong and Sambamurthy 1999; Bassellier, Benbasat and Reich 2003; Thong and Yap 1995). Prior research has examined the TMT in relation to creating a sustainable competitive advantage and achieving superior performance using the Resource Based View of the firm (RBV) (Bharadwaj 2000; Mata, Fuerst, and Barney 1995).

RBV suggests that attributes related to experiences, organizational culture, and technical competencies are critical to the success of the firm (Campbell and Luchs 1997; Hamel and Prahalad 1996). RBV is based on two assertions: (1) the resource and capabilities possessed by competing firms may differ (resource heterogeneity); and (2) these differences may be long lasting (resource immobility). A firm resource that could meet these two assertions includes managerial IT skills. Firms that have managers that have the unique capability of conceiving, implementing, and exploiting IT applications are likely to create IT resources that are rare and firm specific (homogenous) and difficult to duplicate (immobile) thus meeting the two assertions for RBV (Mata et al.1995). The majority of extant studies examining managerial or TMT IT skills have largely ignored the SME market focusing instead on large enterprises (Armstrong and Sambamurthy 1999; Bassellier et al. 2003).

Prior research has established that SMEs differ from large enterprises in several important ways (Premkumar 2003; Buonanno, Faveria, Pigni, Ravarini, Sciuto, and Tagliavini 2005). Key differences include the concentration of decision-making responsibilities to a small number of individuals and the lack of information systems management (Buonanno et al. 2005). Mata et al. (1995) argue that managerial IT skills are valuable and "without them the full potential of IT for a firm will almost certainly not be realized" (p. 498-99). This is particularly true for SMEs that do not have extensive IT departments and therefore must rely on its TMT's IT knowledge and experience to conceive, develop, exploit, and assimilate IT applications that support and enhance their business performance.

ERP Assimilation

IT assimilation refers to the success achieved by firms in utilizing the capabilities of IT to enhance their business performance (Armstrong and Sambamurthy 1999, p. 305). Assimilation of IT is measured in terms of the breadth and depth of its use within the firm (Liang, Saraf, Hu, and Xue 2007). With the increased investment in and reliance on IT by firms, IT assimilation is important as it reflects the extent to which the technology has been absorbed or internalized into the daily routines of an organization.

Existing research suggests that top management support for both large and small enterprises is one of the critical success factors needed for the successful implementation of ERP systems (Loh and Loh 2004). In addition, it is suggested that it is the IT knowledge and experience of the TMT that can have significant influence on the assimilation of technology in the firm (Armstrong and Sambamurthy 1999; Li 2005).

The ERP market is expected to reach $64.8 billion by 2009 which is approximately a thirty six percent increase since 2004 (AMR 2005). The biggest market share is expected to occur in the SME market. Esteves and Bohorquez (2007) suggest that studies on ERP are scant compared to the business they generate (p. 31). They suggest a lack of research on firms with ERP systems in the post-implementation stage. In particular, they suggest a lack of research on the level of integration or assimilation of ERP systems within organizations.

Given the increase in adoptions of ERP systems by SMEs and the potential problems that could arise once implemented, it is necessary to investigate the determinants that help to facilitate ERP assimilation. An objective of this research is to study the impact of the TMT in SMEs that have adopted and implemented ERP systems and to investigate the role that assimilation has on the performance of the firm.

ERP and Firm Performance

In spite of the wide-scale adoption of ERP systems and the momentum they are achieving in the SME market, extant research suggests that the expected benefits of these systems are not always achieved (Botta-Genoulaz, Millet, and Grabot 2005). An ongoing debate is whether these costly ERP systems lead to better firm performance. Overall, the results have been mixed (Hunton, Lippincott, and Reck 2003; Nicolaou, Stratopoulos, and Dehning 2003; Poston and Grabski 2001).

Although these studies have made a significant contribution in the research on ERP systems in relation to adoption and firm performance, they fail to address both the SME market and the level of assimilation of the ERP systems. According to Raymond (2005), adoption of IT by itself does not guarantee higher performance; it is adoption in conjunction with the ability of the firm to assimilate the technology into its business routines that will allow firms to realize the benefits of such technology and thus improve firm performance. This study seeks to add to the ERP literature by evaluating the impact that assimilation has on firm performance.

Commercial Open-Source ERP Software

Of particular interest to this study is the introduction of commercial open-source ERP softwares (COSES). ERP vendors, taking advantage of open-source software technology, have developed ERP systems that are not only more affordable to SMEs but also provide more flexibility than proprietary ERP packages. This study focuses on SME firms using this new ERP format (i.e., COSES) and its impact on assimilation and performance.

There are two classifications of open-source software: community and commercial. *Community open-source software* is software that a "community"[3] develops rather than a single corporate entity. Individual developers make decisions about the software and the developed code is freely available to any user via the internet.

Commercial open-source software lies between community and proprietary software. It is software that a for-profit entity owns and develops and, like community open-source software, is available to the customer in source code form (unlike proprietary software). Like proprietary software vendors, commercial open-source vendors maintain the copyright to the software and determine what code is acceptable in the software base. Beyond the software base, customers are free to customize the software to fit their specific business needs.

[3] Community refers to a group of individuals from all different backgrounds that get together and create software projects that are freely available via the internet. These individuals are not only involved in source code development, but also documentation, bug reporting, and support forums.

ERP vendors, leveraging the open-source technology, are now producing business processing solutions aimed specifically at the SME market.[4] As indicated above, these ERP solutions are referred to as commercial open-source ERP software (COSES). Specifically, COSES are software products that a for-profit vendor owns and develops. COSES vendors differ from traditional ERP vendors in that they give customers full access to the source code while at the same time maintaining the copyright to the software. The customer benefits from the commercial open-source strategy through reduced costs (licensing costs are relatively low compared to large proprietary software programs such as SAP) and increased flexibility (customers are less dependent on the vendor and are free to customize the source code to meet their specific business processing needs).

Traditional ERP vendors, on the other hand, sell customers the right to use "proprietary software" in which the source code is owned by the vendor and customers are not given access to it. These proprietary packages are standardized and are considered a "best practices" or "best of breed" product. Use of proprietary software is restrictive as firms are often required to make significant changes to their business processes in order to "fit" the software package.

Historically, a common problem with traditional ERP systems has been the issue of misalignment between the software capabilities and the organizations business process needs (Soh, Kien, and Tay-Yap 2000). Therefore, when implementing an ERP system, it is critical for firms to decide if their businesses processes will fit within the

[4] For online examples, visit compiere.com, ofbiz.apache.org., or openbravo.com.

"best practices" standards of the traditional ERP systems. If not, a firm must decide whether it is feasible to change their processes to fit the package or to customize the package to fit their processes (customization is often discouraged by the traditional ERP vendors and if chosen the costs can be prohibitive).

COSES address the problems of "misfits" as they provide firms with more flexibility. The major benefits of COSES include low cost of ownership, product control, ownership of source code, freedom from restrictive rules that limit business processes, freedom from vendor lock-in, and security in knowing that the investment will last as long as the firm wants. Ownership of source code provides flexibility in that the ERP system can be adapted or modified at any time to meet the changing demands of the firm by any qualified person. Ownership provides the firm with the ability to maintain their long established business processes particularly those that have been proven to provide the firm with a competitive advantage. Product control can reduce hidden organization, ongoing integration, operational, and maintenance costs.

According to RBV, if a firm possesses a resource capability that is not currently possessed by competing firms, that resource may meet the condition of heterogeneity. COSES by its nature is heterogeneous as it provides firms with product control and allows the firm to create IT resources that are unique and not easily imitated by its competitors. COSES provide firms with flexibility to respond quickly to market demands and to build significant innovation capability. This flexibility is perhaps the most distinct advantage provided by COSES that a SME can possess. In addition, since the firm is in control of the ERP source code, particularly the firm specific

modifications, it is likely that there is a cost disadvantage to competing firms in obtaining and developing that resource.

Of the benefits of COSES, ownership of source code which provides adopting firms with flexibility is particularly important for SMEs with limited resources. SMEs rely on their TMTs' IT knowledge and experience to adopt ERP technology that will allow them to be flexible so as to capitalize on their unique business capabilities. The greater the flexibility of the technology, the more likely a firm is to have a successful implementation and the more likely they are to successfully assimilate that technology into their business. Therefore, implementation of COSES offers SMEs a competitive advantage *not* by competing on IT but through the development of a system that allows a company to increase its competitiveness through the *use* of IT.

Contributions of this Study

Most extant research on ERP has focused on the selection, adoption, and implementation stages on large enterprises acquiring ERP software from large vendors. There is little research on firms in the SME market and on emerging types of ERP systems such as open-source software. The paucity of research on SMEs and emerging ERP systems is likely due to the lack of data availability as a majority of these firms are private rather than public.

ERP systems are a long-term investment requiring tremendous resource commitments. As the format of ERP systems have profoundly changed and the cost of implementing ERP is no longer prohibitive, SMEs are increasingly embracing this innovation. As SMEs play an important role in the U.S. economy, there is a need to

better understand the ways in which SMEs adopt, implement, and assimilate these systems into their business.

Some of the alleged benefits of ERP systems include cost reductions, productivity improvement, customer service improvement, better resource management, and better decision making. In SMEs, the TMT plays a crucial role in the innovativeness of the business. SMEs rely on the TMT to evaluate the appropriateness of adopting IT solutions, such as ERP. The TMT is also instrumental in facilitating the assimilation of new technology into the firm.

In spite of the large scale adoption of ERP systems, several ERP implementations have not lived up to their expectations (Esteves and Bohorquez 2007; Botta-Genoulaz et al. 2005). Thus, the failure of SMEs to properly implement ERP systems can have a devastating effect on both the firm and the economy.

As ERP systems become mainstream applications for both large and small enterprises, these systems change the way that information is processed within a firm. These process changes imposed by ERP, therefore, impact every functional area in the firm including accounting. Despite the radical changes imposed by ERP systems, the accounting research community has largely ignored this topic. In hopes of addressing this literature gap, the International Journal of Accounting Information Systems has issued a call for research on ERP systems (Sutton 2006; Arnold 2006).

This study addresses this literature gap by examining some of the unanswered questions related to the assimilation of unique ERP systems used by SMEs. In particular, this study tests the relationship between the TMTs' IT knowledge and

experience of small and medium sized enterprises and a firm's ability to assimilate an ERP system. The study focuses on firms using commercial open-source ERP software; a new and emerging type of ERP system.

The remainder of this dissertation is organized as follows. The next chapter reviews the relevant literature on ERP systems focusing on studies involving SMEs and their TMT's IT knowledge and IT experience as it relates to both assimilation and firm performance. Chapter 3 provides the theoretical basis and motivation for the hypotheses. The research methodology, including the empirical models and data sources, is identified in Chapter 4. Chapter 5 presents empirical results for the models and supplemental analysis. The final chapter concludes the study with a summary and suggestions for future research.

Chapter 2

Literature Review

Enterprise Resource Planning

ERP systems while not necessarily entirely considered accounting systems are substantially built around accounting processes. Accounting has been defined as the "system of recording and summarizing business and financial transactions and analyzing, verifying and reporting the results."[5] Fundamentally, ERP systems fit within this accounting definition as they are designed to record business transactions for all functional areas of an organization, aggregate these transactions, and ultimately generate reports for both management purposes (reports are analyzed and use to make business decisions) and financial purposes (generate both financial and non-financial performance reports). The Association for Operations Management (APICS) corroborates the idea of ERP systems being an accounting system as it defines ERP as "an accounting-oriented information system for identifying and planning the enterprise-wide resources … ."[6] Although ERP systems are grounded in accounting, studies in the accounting literature are rare.

Accounting ERP Research (Management Control and Auditing)

Recently, scholars from the accounting field have investigated the impact of ERP systems on accounting and management control practices. One study investigated risk factors and control procedures that are critical for the successful implementation of ERP systems (Grabski and Leech 2007). Another study suggests that control in an ERP

[5] www.merriam-webster.com
[6] APICS Dictionary, www.apics.org

environment is not just a property of the accounting function but instead is a "collective affair" of all management functions (Dechow and Mouritsen 2005). Similarly, Granlund and Malmi (2002) in a study on the practical implications of ERP on management accounting, find that implementation of ERP systems have led to only *small* changes in management accounting and control procedures. Testing for a relation between management control and ERP system configuration, Quattrone and Hopper (2005) find that there is a positive relation between the two (i.e., spatial and temporal distance). Finally, in a case study, Scapens and Jazayeri (2003) find that although there was little change in management information used following SAP implementation, management accounting roles did change. For example, managers took on a wider role even though they performed less routine jobs.

Auditing studies have investigated the internal auditor's role in developing and implementing ERP systems. Concerned with the idea that ERP systems can impact a firm's audit and control environment, Cerullo and Cerullo (2000) find that both the integrity and the security of the systems (two variables that can substantially impact a firms control environment) are not being properly investigated prior to implementation. The benefits of embedded audit modules (EAM) have also been explored in terms of their usefulness to auditors. In an exploratory paper, Debreceny, Gray, Ng, Lee, and Yau (2005) show that while EAM's could be useful to auditors assessing ERP systems, ERP vendors are slow to integrate them into the ERP framework due to lack of customer demand.

Notwithstanding the lack of ERP research in accounting literature, ERPs have been extensively studied in the information systems (IS) and operation management (OM) disciplines. A majority of this literature has examined the selection, adoption, implementation, and critical success factors of ERPs. For a comprehensive review of ERP articles published in IS journals during the period of 1997 to 2000, see Esteves and Pastor (2001) and Klaus, Rosemann, and Gable (2000). For the period 2001 to 2005, see Esteves and Bohorquez (2007). For a comprehensive review of ERP articles published in both OM and IS journals during the period 1999 to 2004, see Cumbie, Jourdan, Peachey, Dugo, and Craighead (2005). For the period 2003 to 2004 see, Botta-Genoulaz et al. (2005). Note that the preponderance of these studies focus on large enterprises adopting ERP systems from large vendors.

Small and Medium Sized Enterprises

Small and medium sized enterprises (SMEs) differ from large firms in several important ways. For example, SME decision making is limited to only one or two key players in the firm, bureaucracies are minimal, standard procedures are not well established, long-term planning is limited, and dependence on external expertise and services for information systems operations is greater (Premkumar 2003). Differences also exist in relation to information-seeking practices that impact IT adoption. These differences include lack of information systems management, concentration of information-gathering responsibilities to a small number of individuals, lower levels of resources available for information-gathering, and in the quantity and quality of available environmental information (Buonanno et al. 2005). Because of these

differences, adoption of new technology for SMEs can be risky strategically, operationally, and financially. SMEs are therefore cautious and tend to adopt IT at a much slower rate than larger enterprises.

SMEs play an enormous role in most economies. According to the US Census Bureau, in 2005 SMEs represented approximately eighty six percent of the total establishments (ninety nine percent of the total firms) and accounted for approximately fifty percent of the total employment (U.S. Census Bureau 2005). In relation to the ERP market, several survey companies have reported that the overall demand for ERP systems is growing and that a substantial amount of this growth is expected to come from the SME sector (AMI 2007; Aberdeen 2004; AMR 2005). Despite the numbers of SME firms and the projected increase in ERP usage, there is scant ERP research on SMEs. A summary of this research including information on sample, measures, and findings is shown in Table 1. The paucity of research is likely due to the lack of data availability as the majority of these firms are private rather than public.

[Insert Table 1 about here]

In a comparative analysis between SMEs and large enterprises, findings suggest that business complexity is a weak predictor of ERP implementation whereas size was a good predictor. The data was collected through personal interviews with 122 SME firms from Italy (Buonanno et al. 2005). In a related study, Benroider and Koch (2001) investigate ERP selection process differences between small, medium, and large enterprises. Respondents include 138 Austrian firms. Differences were found in team structure, information gathering methods, and in decision processing methods. Smaller

firms used a more centralized team structure, had less complex, less expensive information gathering methods, and took less time and incurred less expense in the decision process. Comparing large enterprises to SMEs, Shin (2006) suggests that SMEs have an advantage over larger enterprises in the adoption of ERP systems in that SMEs business processes are less complicated allowing for easier adaptation. On the other hand, the author suggests that the risks are higher for SMEs as the cost overruns during implementation may put financial strain on the firm and thus substantially impact firm performance. Other studies have shown that large enterprises differ significantly from SMEs in terms of their operational and strategic requirements (Huin 2004).

Investigating the profile and traits needed for SMEs to successfully adopt ERP systems, Raymond and Uwizeyemungu (2007) assess the characteristics of 356 Canadian SME manufacturing firms based on environmental, organizational, and technological contexts. The environmental context suggests that firms that operate in a price-sensitive market need integrated systems in order to have control over its production costs. Firms operating in a dynamic sector or high growth sector need information systems (IS) that allow it to respond quickly to change. Firms operating in a network intensive environment (i.e., close logistical links with their business partners) require the need for optimal supply chain systems integration. Each of these environmental characteristics identified above was shown to influence a firm's decision to adopt an ERP system. For the organizational contexts variables, firm size, type of production and operation, innovation, and financial capacity were shown to influence a

firm's decision to adopt ERP systems. Finally, a firm's technological context was also shown to influence a firm's decision to adopt an ERP system (technological context was measured in terms of how autonomous or integrated firms' existing systems were and the level of assimilation achieved for each adopted technology). The empirical results suggest that it is important for firms contemplating adopting ERP systems to assess their level of systems assimilation within both the organizational and environmental context. Overall, the findings show that level of systems assimilation was found to be an important predictor in determining whether the adopted ERP system would be aligned with the SME's competitive environment, strategic objectives, and manufacturing structure.

Using the same database of Canadian SMEs as Raymond and Uwizeyemungu (2007), Raymond (2005) examines the association between critical success factors (CSF) and level of systems assimilation of advanced manufacturing technologies (AMT) such as ERPs. The study finds that a mismatch between CSF and AMT assimilation negatively influences performance.

Little research has been published on IS adoption by SMEs. An exception is a study by Thong (1999) which considers decision-maker characteristics as determinants of adoption. The study investigates 166 SME firms in Singapore and finds that CEO characteristics such as level of IS knowledge and CEO innovation are important determinants of IS adoption.

In a study examining whether ERP systems provide SMEs with a competitive advantage in product delivery for made-to-order, made-to-stock, and mixed-mode

manufacturing firms, Koh and Simpson (2007) survey 126 United Kingdom (UK) managers. The results indicate that ERP systems can create a competitive advantage for SMEs in the delivery of products through functionality that allows them to be more responsive and agile to change (i.e., in production and product design).

Finally, Olsen and Saetre (2007), in a unique article, investigate whether or not proprietary ERP software is a better alternative for SME firms than in-house developed ERP software. The authors conclude that SME's survival strategy depends on its ability to be flexible, innovative, and efficient. They argue that proprietary software is not a better alternative than in-house developed ERP software as it reduces a firm's ability to be idiosyncratic by requiring the firm to adopt a *standard* way of doing business. Instead, the authors propose that in-house developed ERP systems are more advantageous to SMEs as they allow them to concentrate on their core IT functions thus increasing their competitive position through the use of IT.

Assimilation

IT assimilation has been defined as the "effective application of IT in supporting, shaping and enabling firms' business strategies and value chain activities" (Armstrong and Sambamurthy 1999, p. 306). It has also been defined as the "extent to which the use of technology diffuses across organizational work processes and becomes routinized in the activities associated with those processes" (Chatterjee, Grewal, and Sambamurthy 2002, p. 66). Thus, with the increase investment in, and reliance on IT by firms, IT assimilation is more important than ever as it reflects the extent to which technology has been absorbed or internalized into the daily routines of an organization.

As new IT is adopted and progresses through the stages of assimilation, it gradually advances from its initial adoption to its wide-spread use within the firm. Assimilation is particularly important for firms as they adopt more complicated and far reaching knowledge systems such as ERP. It is important to note that ERP systems differ largely from other IT systems in that they are complex systems impacting a broad range of business functions and implementation requires coordination and participation from many components of the firm (i.e., operational, technological, managerial, and strategic) (Ifinedo 2007). There has been much written on the difficulties experienced in the adoption and implementation phases of ERP projects (the review of such research is presented above), however there is a dearth of research examining the post-implementation and assimilation phases.

ERP assimilation represents an important outcome for a firm as it impacts not only the organizational processes but also its overall business strategy and ultimately its performance. Extant research suggests that in order for a firm to realize the full business value of new IT, successful assimilation of the technology is required (Armstrong and Sambamurthy 1999; Zmud and Apple 1992; Kouki, Pellerin, and Poulin 2007). Therefore, as ERP adoption rates increase and firms make significant investments in the technology, it is vital for firms to successfully implement and fully utilize the technology in order to realize the desired benefits.

IT Assimilation

Despite its importance, there is scant empirical research in the area of IT assimilation, particularly in the area of complex IT systems such as ERP. Descriptive

studies on IT assimilation include the development of assimilation frameworks for emerging technologies such as ERP (Bajwa, Garcia, and Mooney 2004), decision support systems (Hayen, Holmes, and Scott 2004), electronic data interchange (Massetti and Zmud 1996), supply chain management (Tracey, Fite, and Sutton 2004), e-business (Vaidya, Sajeev, and Gao 2005), and value chain activities (Li 2005).

Empirical studies on IT assimilation *other than ERP* include IT assimilation in relation to TMT IT knowledge (Armstrong and Sambamurthy 1999), human resource factors (Martinsons and Chong 1999), e-commerce and e-business (Raymond 2001; Raymond, Bergeron, and Blili 2005; Chatterjee et al. 2002) and on emerging information systems technology such as object-oriented programming languages (Fichman and Kemerer 1997) and electronic scanners (Zmud and Apple 1992).

ERP Assimilation

Although the research community has been slow in publishing studies on ERP assimilation, it has received some attention in the past few years. A summary of this research including sample, measures, and findings is presented in Table 2.

[Insert Table 2 about here]

In 2005 there were at least three studies on ERP assimilation. In one study, Vluggen (2005), drawing on diffusion of innovation theory, conducted a survey of 502 Dutch organizations that adopted SAP systems. The independent variables (IVs) examined include external, internal, and innovation characteristics of the firm. These IVs were tested in association with the usage level of each ERP module (usage is measured as time since adoption). Five control variables, including business size,

elapsed time, top management support, and two industry variables, that could potentially impact a firm's decision to adopt an ERP system were included in the study. Multiple regression analysis was used to test each hypothesis. The findings indicate that for the internal variables, ERP usage is positively associated with information intensity and negatively associated with centralization. No association is detected between ERP adoption and the formalization variable. For the external variables, ERP usage is positively associated with external pressure. However, no relation is found with environmental uncertainty. For the innovation variables, ERP usage is positively associated with perceived relative value but no association is found with compatibility or complexity. For the control variables, elapsed time since the initial introduction of ERP is positively and significantly related to ERP usage as were the industry variables for manufacturing and wholesale/retail firms. No relation is found between ERP usage and top management support or firm size.

In a second study, Papastathopoulou, Avlonitis, and Panagopoulos (2005) explore intraorganizational diffusion[7] of information and communication technologies (ICT) (e.g., ERP systems) in relation to marketing-related and non-marketing-related functions of a firm. Participants of the study include IT managers from 500 firms in Greece. The study employs structural equation modeling to test the relationships between several ICT characteristics (antecedents) and marketing related diffusion variables and performance measures (consequences). The consequences include marketing effectiveness, communication/informational effectiveness, and financial

[7] Intraorganizational diffusion refers to the process of understanding, mastering, and using adopted technology; in this sense it is similar to assimilation.

effectiveness. Overall the study provides evidence that marketing-related ICT diffusion is positively associated with performance.

In a third study, Raymond (2005) applies contingency theory to examine the link between assimilation of advanced manufacturing technologies (AMT), such as ERP, and operational performance. Assimilation is measured based on the respondents perceived level of proficiency for each AMT adopted in the firm (based on a scale of 1-low to 5-high). Operational performance is measured in terms of a firm's productivity, cost reductions, flexibility, quality, and integration. The study is conducted using survey methodology. The participants include production managers from 118 SME Canadian manufacturing firms. Empirical testing is conducted using partial least squares (PLS) and the results suggest that firms that are more proficient with their use of AMT (i.e, achieve higher levels of assimilation) are more likely to attain higher levels of operating performance.

In another study employing case methodology, Kouki et al. (2007) test the influence of an ERP assimilation framework on a firm's ability to assimilate the ERP system into the business. The framework includes organizational, technological, and environmental factors. ERP assimilation is measured using three criteria: the significance of decisions made using the system, the significance of activities supported by the system, and the level of acceptance by the users of the system. The case analysis is based on three Canadian manufacturing firms. The study conjectures that ERP assimilation is facilitated by smaller firms with fewer employees, the presence of IT

skills and competence, a top management champion, and alignment with a firm's business strategy.

In the most recent publication on enterprise systems assimilation, Liang et al. (2007) develop and test a model that explains how the TMT of a firm mediates the impact of external pressures on the degree of assimilation of ERP systems. The study assesses the mediating role of top management beliefs and participation between institutional forces (mimetic, coercive, and normative[8]) and ERP assimilation. Adapting a model developed by Massetti and Zmud (1996), the authors construct an assimilation measure consisting of a three-item scale (volume, diversity, and depth of ERP usage). Volume represents the percentage of the firm's business processes that are using the ERP system. Diversity represents the number of functional areas in the firm using the ERP system. Depth measures, for each functional area, the level at which the system is being used. The study includes five control variables including absorptive capacity, organizational size (both in terms of employees and revenue), organizational compatibility, and time since implementation. Participants of the study include directors from 77 Chinese firms that have implemented an ERP system. Empirical testing was conducted using PLS analysis. The results provide evidence that institutional pressures on ERP assimilation are partially mediated by top management. The findings also suggest that institutional pressures, which have been shown to be important for IT adoption and implementation, are also significant for IT assimilation.

[8] Mimetic forces refer to the mimicking of another firm's actions. Coercive forces refer to the external pressures exerted on firms by other organizations to which they are dependent. Normative forces refer to institutional norms imposed primarily through professionalization.

In today's highly competitive markets, a firm's ability to assimilate IT applications, such as ERP, is critical to its success (Armstrong and Sambamurthy 1999; Liang et al. 2007). Despite its importance, only a few studies have been devoted to uncovering the factors that influence the assimilation of ERP systems within an organization. The results of the existing studies confirm that ERP systems when successfully assimilated into the firm can be significant both operationally and strategically. However, the sample populations used in these studies are limited to international firms and with the exception of Liang et al. (2007) assimilation is measured based on only one dimension.

ERP and Firm Performance

Extant research in relation to ERP and firm performance is dominated by studies using large, publicly traded organizations adopting large ERP systems. These studies focus on performance during the early stages of ERP including the evaluation, selection, adoption, and implementation stages. Few ERP studies investigate performance measures in the post-implementation stage (e.g., assimilation stage).

Several ERP studies have taken an economic-based focus examining both stock returns and accounting metrics. The results of these studies have been mixed. A summary of this research including information on sample, measures, and findings is shown in Table 3.

[Insert Table 3 about here]

Hendricks, Singhal, and Stratman (2007) examine the impact of long-term stock returns and two accounting metrics: return on assets and return on sales. The sample

consists of large publicly-traded firms that have announced the adoption of ERP systems during the period 1991 to 1999. Reporting the results of non-parametric tests, the authors find mixed results. In the two-year implementation period abnormal returns are negative and statistically significant. In the three-year post implementation period abnormal returns are positive and statistically significant. In the five-year post implementation period there is no evidence of abnormal returns.

In another study, Poston and Grabski (2001) examine the impact on four financial measures before and after ERP adoption. The sample consists of public firms announcing the adoption of ERP systems by one of the top five ERP vendors during the period 1980 to 1997. The study reveals improvements in the ratio of employees to revenue. However, all other metrics show no improvement. Nicolaou et al. (2003) also use financial ratios to examine firms adopting ERP systems. Using a matched control group the study shows that firms adopting ERP systems have significant performance improvement in the second year after implementation. The sample used consists of large public firms announcing ERP adoption during the period 1990 to 1998.

Similarly, Hunton et al. (2003) compare ERP adopters to non-adopters using a matched-pair design. Assessing performance using financial metrics, the study does not find performance improvements for the adopters. Interestingly however, the study does find that unlike the adopters, the performance of the non-adopters declines in the test period. The sample for this study, similar to those presented above, consists of large public firms announcing ERP adoption during the period 1990 to 1998.

Reactions of ERP analysts to adoption of ERP systems are also investigated. In an experiment, Hunton, McEwen, and Wier (2002), investigate the extent to which investors believe that adoption of ERP systems enhance firm value. Examining changes in financial analysts' earnings predictions before and after a firm announces plans to implement an ERP system, the experiment shows that analysts overall reactions were positive.

Wieder, Booth, Matolcsy, and Ossimitz (2006) also examine the difference between ERP adopters and non-adopters. The study examines differences between these two groups at the supply-chain level and the overall firm level. Both financial and non-financial measures are used including return on investments, sales growth rate, cost reduction, and liquidity. The sample consists of 102 Australian firms. The findings suggest no significant performance differences between the two groups. Shin (2006) using an econometric model, assess the effect of enterprise applications (i.e., ERP) on productivity for 525 Korean SME firms. The findings suggest that ERP adoption has an insignificant effect on firm-level productivity.

Other ERP studies have investigated non-financial performance measures in relation to firm performance. Wier, Hunton, and HassabElnaby (2007) use archival data on ERP adopting firms between the period 1992 to 1998 to assess whether the joint adoption of ERP systems and the inclusion of non-financial performance indicators (NFPI) in executive contracts results in greater performance than either ERP adoption or NFPI alone. Empirical findings indicate that firms that adopt ERP and use NFPIs

have higher short-term and long-term performance, as measured by return on assets and stock returns, compared to those firms that only adopt ERPs or only use NFPIs.

In a study using operational measures (i.e., inventory, cost of goods sold, operating income, and selling and administrative expenses) to assess efficiency improvements in medium-sized firms implementing ERP systems in the chemical and pharmaceutical industry, Vemuri and Palvia (2006) find no improvements in their measures of operational efficiency. Other studies that have shown improvements related to ERP in performance ratios, productivity and market valuation, liquidity, and operational effectiveness (Matolcsy, Booth, and Wieder 2005; Hitt, Wu, and Zhou 2002; Karimi, Somers, and Bhattacherjee 2007).

Studies have examined ERP based on Delone and McLean's (1992) information success model. Ifinedo (2007) adapted Delone and McLean's model to create an ERP system success measure that includes variables relating to system and information quality and individual, workgroup, and organizational impact. The author tests the model using 29 firms from Finland and Estonia. Using PLS they find that increases in system quality and information quality increases individual impact, increases in individual impact increases workgroup impact, and increases in workgroup impact increases organizational impact. They find no significant association between individual impact and organizational impact.

In a similar study, Tsai, Fan, Leu, Chou, and Yang (2007) also use Delone and McLean's (1992) model to explore the relationship between implementation variables and performance. Survey data was gathered from 45 Taiwan ERP project managers

relative to implementation status, system source, and strategy. The factors that had the largest effect on performance were in-house developed ERP systems and the implementation of all planned modules. Firm size was not found to have a significant impact on performance.

ERP studies have also explored the relationship between user satisfaction and firm performance. In a study using 206 Taiwan firms, Yang, Ting, and Wei (2006) find that good communication and training, implementing customized ERP packages, and user age, position, and department all have a significant impact on performance.

Although the studies mentioned above make a significant contribution in the research on ERP systems in relation to firm performance, they fail to take into consideration the level of assimilation of the ERP systems. Systematic differences may exist with regard to a firm's ability to assimilate ERP systems into the firm and these differences may impact performance. In addition, these studies focus on firms that have adopted ERP systems and adoption by itself does not guarantee higher performance. It is adoption in conjunction with the ability of a firm to assimilate the technology into its business routines that allows the firm to realize the full benefits of such technology and thus improve firm performance (Raymond 2005).

ERP Assimilation and Firm Performance

As the need for system integration, globalization, and networking with external entities becomes more important and the decision by SMEs to invest in ERP systems increase, a firm's ability to successfully assimilate ERP systems takes on increased significance. Successful system integration, globalization, and networking may be

directly related to a firm's ability to assimilate ERP systems into the firm. Thus, assimilation may impact a firm's survival, growth, and competitiveness, regardless of size.

Despite its importance, the issues surrounding ERP assimilation and firm performance have not been sufficiently addressed. Of the studies reviewed above, only one addresses both assimilation and firm performance (Raymond 2005). A limitation of this study is that the study tests for a relation between the assimilation of all advanced manufacturing technologies adopted by a firm and firm performance. However, in the study only twenty five percent of the firms surveyed had actually implemented an ERP system. The proposed study overcomes this limitation by testing the relation between assimilation and firm performance using a sample of firms that have *all* implemented an ERP system.

Top Management Team and IT Knowledge and Experience

With the increased importance of IT in organizations, the TMT is now expected to show strong knowledge and leadership in its deployment. Mata et al. (1995) drawing upon RBV theories of the firm, argue that managerial IT skills are valuable and "without them the full potential of IT for a firm will almost certainly not be realized" (p. 498-499). The benefit of having adequate managerial IT skills is that it enables a firm to manage the risks associated with investing in IT. This is particularly true for SMEs that do not have extensive IT departments and therefore must rely on its TMT IT knowledge to conceive, develop, exploit, and assimilate IT applications that support and enhance firm performance.

The majority of studies examining TMT IT knowledge and experience in relation to firm performance have largely ignored the SME market. In addition, existing studies have failed to take into consideration the impact that the level of IT assimilation may have on performance.

Few studies have examined the influence of a firm's TMT on the firms' ability to assimilate IT into the business. Of those studies published, the results have been mixed. In a seminal study surveying large U.S. firms listed in Fortune 500, Service Fortune 500, and Business Week 100, Armstrong and Sambamurthy (1999) examine the quality of a firm's senior leadership and their influence in successful assimilation. Senior leadership is defined in this study as the Chief Executive Officer (CEO), the Chief Operating Officer (COO), the Chief Financial Officer (CFO), and the Chief Information Officer (CIO). The quality of the senior leadership is measured using two constructs: senior leadership knowledge and systems of knowing[9]. The IT assimilation construct focuses on firm performance in the *use* of IT and is measured by asking participants to evaluate their firm's performance using non-financial measures compared to other firms in their industry. PLS was used for hypothesis testing. The findings suggest that the CIO's business and IT knowledge significantly influences the firms' IT assimilation. However, the senior business executives IT knowledge *was not* found to influence IT assimilation.

[9] Systems of knowing are referred to by Armstrong and Sambamurthy (1999) as the "structures guiding interactions among senior leadership members to facilitate their dialog and sharing and exchange of knowledge" (p. 307).

A limitation of the Armstrong and Sambamurthy (1999) study is its inability to generalize to SME firms due to its focus on large enterprises. That is, in a large enterprise it may be realistic to expect the senior executives to rely on the CIO for IT strategic guidance so as not to duplicate roles. However, in SMEs where the strategic decisions are made by only one or two key players (the top executives) and where there are fewer resources to invest in extensive IT departments, the burden is on the TMT to be knowledgeable about IT and how it can be strategically deployed.

Firms' TMT's IT knowledge and IT experience has been investigated in relation to management's intention to champion IT. The findings support the view that IT knowledge and IT experience of a firms' TMT is necessary for the successful implementation and assimilation of IT. Surveying 404 members of the TMT (i.e., business managers) for two insurance organizations in North America, Bassellier et al. (2003) find that both IT knowledge and IT experience positively influences a manager's intention to champion IT. They contend that the success of a firm, in an increasingly competitive market, depends critically on the quality of IT knowledge for which it possesses and its ability to apply that knowledge to their key business processes. Similarly, Raymond et al. (2005) examine chief executive's experience and education level relative to the assimilation of e-business. They also find a positive association between executive's experience and assimilation in an e-business setting but find no association between executive's education and assimilation.

Based on the theory of social learning, Ettlie, Perotti, and Joseph (2005) conclude that senior managers must have sufficient knowledge of new IT so that they

can demonstrate through example its necessity to the organization. They test the hypothesis that leadership through example promotes successful IT adoption using 60 large US firms listed in the Fortune 1000. The results indicate that leadership is a significant predictor of adoption performance (as measured by percentage of project completion and adoption status relative to competitors).

Similarly, Jarvenpaa and Ives (1991) find that a CEO's personal participation in IT is moderately associated with a firm's progressive use of IT[10]. They argue that when a firm's TMT has higher levels of IT knowledge, they are more likely to feel involved with IT issues and will be more strongly associated with the firms' use of it. The study is conducted on 83 Fortune 500 firms in the banking, publishing, petroleum, and retailing industries.

Finally, Baskerville, Pawlowski, and McLean (2006) in a study using case methodology investigate how ERP systems impact organizational knowledge. They find that business experts and executive management teams need to have knowledge not only on the core business but also on the technology used within the firm in order to successfully assimilate IT into the business. The case study was conducted at a Fortune 100 manufacturing firm in Atlanta, GA.

The association between TMT characteristics such as knowledge, age or education, and IT use has also been investigated. In a study using 132 organizations belonging to GUIDE International, a professional association of IBM system users,

[10] Progressive use of IT is the dependent variable in Jarvenpaa and Ives (1991) study. It represents the firm's use of IT relative to competitors in the same industry. Progressive use is measured on a scale ranging from industry leader to laggard.

Boynton, Zmud, and Jacobs (1994) test if higher levels of managerial IT knowledge is directly associated with the extent of IT use. Using structural equation modeling (SEM) to test their model, the authors *do not* find a significant path between managerial IT knowledge and IT use. On the other hand, Jarvenpaa and Ives (1991) hypothesize that CEO background and their personal participation in IT management will be associated with a firm's use of the IT. They find that age and education are positively associated with the progressive use of IT. Other empirical studies have also found characteristics such as managerial tenure, education level, and professionalism to be significant predictors of IT assimilation (Damanpour 1991; Fichman and Kemerer 1997).

Top management support is considered a critical success factor in a firm's ability to successfully implement IT. In addition, it has also been found to be an important determinant in a firm's decision to adopt IT. In studies evaluating critical success factors for IT projects including ERP, findings suggest that top management support is critical to successful implementation (Raymond 2001; Bingi, Sharma, and Godla 1999; Ettlie et al. 2005; Finney and Corbett 2007; Skok and Legge 2001). In studies evaluating top management support relative to IT adoption decisions, findings suggest that the decision to adopt IT is positively associated with firms top management support (Mehrtens, Cragg, and Mills 2001; Thong and Yap 1995; Thong 1999).

There have been several failed ERP attempts by both large and small enterprises such as Hershey Foods, FoxMeyer Drug, Mobil Europe, Dell Computer, and Dow Chemical (Davenport 1998; Bingi et al. 1999; Markus and Tanis 2000; Muscatello et al. 2003; Olsen and Saetre 2007). Successful implementation of an ERP system is critical

as it is extremely difficult, if not impossible, to undo the changes that ERP systems bring to a company when implemented. Smaller firms with limited resources are less likely than large enterprises to recover from a failed ERP implementation attempt (Muscatello et al. 2003). Extant research has found the TMT to be critical to the success of IT assimilation. However, few studies have investigated the impact of a firm's TMT in relation to IT assimilation and firm performance for SME firms. As the adoption of ERP systems by SMEs increase, it is important to determine whether the TMT's IT knowledge and experience are determining factors in the systems use and whether the level assimilation achieved for the technology has an impact on firms' overall performance.

Commercial Open-Source ERP Software

Historically, a common problem with proprietary ERP systems has been the issue of misalignment between the software capabilities and the organizations business needs (Soh et al. 2000). Commercial open-source ERP software (COSES) alleviates the misfit problem by putting control of software in the hands of the adopting firms. COSES is unique in that it provides firms access to the ERP source code which gives the firm the flexibility to align the system to fit their specific business needs through in-house customization.

There is scant research published on firms that have adopted COSES. In a unique study, Glynn, Fitzgerald, and Exton (2005) investigate the factors contributing to the adoption of open-source software from an environmental, individual, organizational, and technological perspective. The study gathers data from 111 individuals from a

single case study conducted at a hospital. Employing non-parametric tests, the findings reveal that the ability to modify the ERP system to fit the business needs, the availability of open-source literate personnel, the presence of top management support, the existence of an open-source champion, and limited financial resources were all significant factors contributing to the adoption of open-source software.

Descriptive studies have analyzed open-source enterprise systems as an alternative to proprietary ERP software (Dreiling, Klaus, Rosemann, and Wyssusek 2004, 2005; Serrano and Sarriegi 2006). These studies suggest that dissatisfaction with proprietary enterprise systems stems primarily from cultural misfits between business processing needs and the best practices solutions provided by proprietary ERP systems. Distinct characteristics of open-source software include support for open standards and open data formats, customizability, support for improved quality, and support for faster, less costly system development (Dreiling et al. 2005). Benefits include increased adaptability, decrease reliance on a single vendor, and reduced costs (Serrano and Sarriegi 2006).

ERP systems have historically been too costly for SMEs. The introduction of innovative ERP software such as COSES has created a whole new generation of ERP solutions. SMEs are no longer forced to adopt proprietary ERP systems that require them to accept rigid, generic solutions reflecting the vendor's view of what best practices should be rather than reflecting the firm's view of their best practices. SMEs survival strategy and its strategic advantage lie in its ability to implement IT that allows it to be agile, flexible, and innovative. Adopting COSES provides SMEs with the

flexibility they need to maintain their core business functions that have ultimately provided them with a sustainable competitive advantage.

Chapter 3

Theoretical Framework and Development of Hypotheses

Resource-Based View of the Firm

The theoretical motivation for studying the relationships among TMT's IT knowledge and IT experience, assimilation, and firm performance, is based on the resource based view of the firm (RBV). RBV proposes that firms possess unique resources some of which provide the means to achieve competitive and strategic advantages and some of which provide the means to achieve superior long-term financial performance. Extant research suggests that only resources that are valuable, rare, inimitable, and for which there is no substitute, can provide a firm with a sustainable competitive advantage (Wernerfelt 1984; Barney 1991).

The RBV of the firm implies that organizations differentiate themselves from competitors based on their unique resources and capabilities. It is only when those resources are protected from imitation that the firm is able to achieve a sustainable competitive advantage. A firm's strategy should be constructed around those unique resources and capabilities allowing the firm to best exploit its core competencies (Hint, Ireland, and Hoskisson 2006).

Broadly defined, firm resources represent "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve efficiency and effectiveness" (Barney 1991, p. 101). Prior research based on RBV theory argues that IT resources and managerial IT skills are examples of resources that firms can use to

differentiate themselves from their competitors. Barney (1991) suggests that the TMT is a critical resource because of its impact on a firm's strategic decision-making and on the implementation of those decisions. Others argue that when firms are able to differentiate themselves based on managerial IT skills and resources, they are better able to achieve higher levels of IT assimilation and firm performance (Bharadwaj 2000; Mata et al. 1995; Armstrong and Sambamurthy 1999; Santhanam and Hartono 2003).

Mata et al. (1995), in an exploratory study, identifies managerial IT skills as a resource that is likely to be a source of sustained competitive advantage as these skills are likely to be rare, firm specific, and difficult to duplicate. Bharadwaj (2000) argue that knowledge-based resources such as IT knowledge when combined with tangible IT resources create organizational IT capabilities. Thus, firms that are able to successfully create IT capabilities are more likely to achieve superior firm performance.

Bharadwaj (2000) defines IT capabilities as the "ability to mobilize and deploy IT-based resources with other resources and capabilities" (p. 171). The study identifies 149 firms with superior IT capability through industry rankings provided by InformationWeek for the period 1991 to 1994. Data related to firm performance is obtained from Compustat. Using a matched control sample, the findings reveal that profit ratios were significantly higher for firms that were considered as IT leaders as compared to firms in the control group. In terms of cost ratios, both operating expense to sales and cost of goods sold to sales were lower for IT leaders; however, selling and administrative expenses were higher.

Armstrong and Sambamurthy (1999) draw on RBV and knowledge-based theory to hypothesize that firms' with superior senior leadership knowledge and systems of knowing are more adept at exploiting IT innovations and thus are more likely to achieve higher levels of assimilation. Based on RBV theory, the authors' conjecture that IT, when successfully assimilated provides firms with a competitive advantage through operational flexibility, enhanced internal and external relations, and enhanced innovation. The study finds that CIO IT knowledge is positively related to IT assimilation. The study fails to find an association between the IT knowledge of other executive members and IT assimilation.

In a rapidly changing and competitive market, firms that employ IT in such a manner that it allows them to be more agile, flexible, and alert to market changes, may have a resource that is unique in that it sets them apart from their competitors (Barney, Wright, and Ketchen 2001). This is particularly important for SMEs, as flexibility is likely to be one of the most distinct advantage they have (i.e., flexibility allows SMEs to change quickly in response to market demands and allows them to build significant innovation capability) (Nieto and Fernandez 2006). Barney et al. (2001) suggests that the interface between skilled users and unique IT may not be easily duplicated by competitors and that these variables taken together may be a source of a sustainable competitive advantage. Bharadwaj (2000) also argues that IT resources can only generate a competitive advantage when leveraged with other unique firm resources and skills.

High levels of IT knowledge and experience have been found to enhance IT assimilation and performance. Caldeira and Ward (2001) show that IS/IT competencies of the TMT are important determinants that help to explain relative IS/IT success. Studies that find a relation between IT competencies and firm performance include Bharadwaj (2000). Studies that find a link between assimilation and firm performance include Liang et al. (2007) and Raymond (2005). Studies that find a tie between IT competence and championing IT include Bassellier et al. (2003).

In the context of RBV, a resource has value when it enables a firm to implement strategy that improves its efficiency and effectiveness (Barney 1991). As a strategic resource, the TMT is valuable as it is charged with making strategic IT decisions that impact both the efficiency and effectiveness of the firm. RBV contends that a resource must be unique or rare. TMT IT knowledge and IT experience may be considered unique or rare if it derived from firm specific organizational knowledge. RBV also implies that a resource must be difficult to imitate. In the context of this study, the TMT when taken as a whole is made up of a complex set of individual characteristics and attributes that result in a dynamic and socially complex body that is difficult to imitate. Finally, the RBV suggests that a resource must be non-substitutable. The TMT of a firm is difficult to substitute due to the firm specific knowledge it possesses and to its complex social framework.

The TMT of large enterprises has been widely researched. However, little research has been published on the TMT of SMEs. Caldeira and Ward (2001) suggest that IT experience is likely to be the rarest amongst SMEs. They contend that the IT

skills possessed by these firms are likely to be a source of competitive advantage. Therefore, a purpose of this study is to fill this research gap by employing RBV to develop theoretical links between SMEs TMTs knowledge and experience in relation to both its ability to assimilate technology into the business and in relation to the firms overall performance. Therefore, the study hypothesizes the following (in the alternate form):

Hypothesis 1a: Higher levels of TMT IT *knowledge* positively influences ERP system usage which in turn leads to higher levels of ERP assimilation in the organization.

Hypothesis 1b: Higher levels of TMT IT *experience* positively influences ERP system usage which in turn leads to higher levels of ERP assimilation in the organization.

Hypothesis 2: Higher levels of ERP *assimilation* will result in higher levels of operational performance.

Commercial Open-Source ERP Software and SMEs

It is believed that organizations adopt IT to improve their performance through the creation of competitive and strategic advantages (Mata et al. 1995). Zhang and Lado (2001) contend that in order for a firm to achieve such advantages, they must exploit IT in such a way that they leverage their unique operational resources and capabilities. RBV stresses that in order for a firm to differentiate itself from their competitors, the resources deployed must be unique. The implementation of generic ERP processes result in broadly similar business processes and IT infrastructure thus reducing the ability of a firm to gain a competitive advantage from deploying such technology.

Reed and DeFillippi (1990) argue that the skills and resources of a firm that allow it to generate causal ambiguity can result in a competency-based advantage. They argue that core competencies that are complex and difficult to imitate can generate ambiguity and that ambiguity is derived through a combination of skill and resource specificity. Therefore, complex business processes that are unique and result from firm resources and skills that are highly specific and interdependent, may result in ambiguity and thus result in a core competency that is difficult to imitate.

COSES are an example of a unique resource. Unlike generic ERP systems, COSES provide a firm with the agility and flexibility necessary to stay competitive. COSES provide firms with a resource that will allow them to create unique business processes that are idiosyncratic - a characteristic that is central to RBV. Firms choosing to adopt COSES can leverage this technology by focusing on only those key processes which make them different. As COSES progress over time, these processes become more abstruse and difficult for competitors to duplicate.

Extant research argues that since IT investments are easily duplicated, investments in technology alone may not provide a firm with a sustained advantage (Mata et al. 1995). Instead they suggest that it is how the firm leverages the IT investment that allows it to create a unique IT resource (Bharadwaj 2000). Generic ERP packages are an example of a technology that is readily accessible to any firm and thus by itself does not provide a firm with a strategic advantage. However, modifications to these packages allowing the firm to exploit their unique business processes, combined with managerial competencies such as IT knowledge and IT experience, may provide a

firm with the resource-based competency needed to sustain such an advantage (Armstrong and Sambamurthy 1999; Bassellier et al. 2003). IT specific knowledge that comes from experience as well as more general IT knowledge that is obtained from higher education will influence the TMTs awareness of and adoption of advanced technologies such as COSES. Therefore, this study hypothesizes the following (in the alternate form):

Hypothesis 3: Higher levels of COSES customization will result in higher levels of operational performance.

Hypothesis 4: The higher the level of COSES customization, the higher the TMT will perceive its competitive advantage to be.

Chapter 4

Research Methodology

Data Source

The participants in this study are members of the TMT from firms that have adopted commercial open-source enterprise resource planning systems from a single vendor. The subjects for the study consist of the chief executive officer, the chief financial officer, the chief information systems officer, the chief operations officer, and other pertinent members of the TMT. The firm has approximately 500 national and international customers with contact information for over 1000 TMT members.

The Survey

A survey questionnaire was used to collect the data for this study (see Appendix A). The survey instrument was developed and appropriate measures selected based on prior research. The instrument was administered via the internet using a web-based survey. With web-based surveys, the instrument is available on a website and participants are solicited by email, mail, telephone, or through other web sites (Granello and Wheaton 2004). For this study, potential respondents received an e-mail outlining the purpose of the study and inviting them to participate. A link to the survey website was embedded in each email. All responses were collected anonymously using an established and secure web-based survey company. A total of 1,044 surveys were emailed to potential respondents. Of those, 429 were returned as undeliverable (the vendor database contained email addresses for prospective ERP customers as well as for active customers), 24 were eliminated as they had either just implemented the ERP

system or had stopped using the system entirely, and 23 were incomplete resulting in a potential sample size of 618. A total of 164 surveys were completed for a twenty nine percent final response rate.

Advances in technology such as the internet have revolutionized the ways in which surveys are administered. Web-based surveys are just one example of the internet methods that have gained wide acceptance among academic researchers. Web-based surveys offer a multitude of advantages over alternative survey formats. These advantages include flexibility in delivery, diversity in question format, faster response rates resulting from electronic data capture, easier follow up, faster and more efficient data processing, the potential for larger more inclusive samples, and the ability to obtain additional response-set information such as respondent versus non-respondent characteristics (Couper 2000; Granello and Wheaton 2004; Evans and Mathur 2005; Beeler, Franz, and Wier 2001; Cobanoglu, Warde, and Moreo 2001).

A concern with survey research is low response rates. If response rates are exceedingly low, it may raise doubts concerning the validity of the study findings. Non-response presents a problem when it can be demonstrated that there are systematic differences between the respondents and non-respondents (Smith 2003). Web-based surveys enable the researcher to better manage non-responses as electronic data collection provides a vehicle to analyze and measure the impact of non-responses on the study. In the proposed study, the target population is determined via a pre-established customer list. Sampling from a list, via a web-survey, allows the researcher the ability to easily measure non-response rates.

Another advantage of web-based surveys is the potential to improve response rates through the implementation of survey design that accommodates ease of use and allows for easier follow up (Couper 2000). Web-based survey companies provide the researcher with the features needed to design survey instruments that are easy to understand and complete, motivate the respondent, and ensure confidentiality. Web-based surveys further provide the researcher with tools that may alleviate problems related to technical issues such as platform compatibility. Higher response rates resulting from web-based surveying, in turn, may improve statistical conclusion validity[11] thus increasing statistical power and reducing beta error (Bryant, Hunton, and Stone 2004). Finally, a well-designed web-based survey instrument that prevents participants from entering invalid responses improves statistical conclusion validity by decreasing or even eliminating data entry errors (Bryant et al. 2004).

A validity concern with web-based surveys is sample bias or coverage bias. Sample bias can result from limiting responses to individuals who are computer literate or result from the reluctance of individuals to participate due to fear of privacy concerns. Sample or coverage bias may be less of a concern in studies that target specific populations where internet access may be high (Solomon 2001). The proposed study targets respondents from firms that have adopted complex information technology systems. It is therefore expected that the respondents will be computer literate and have nearly ubiquitous access to the internet, mitigating sample bias and coverage concerns.

[11]Statistical conclusion validity refers to the extent to which one can make correct decisions regarding the truth of the null hypothesis (i.e., whether the variables are related to one another).

The proposed survey relies on self-reported and perceptual measures which may also lead to validity concerns. The study argues that the use of the TMT's perception of performance relative to other competing firms is appropriate when compared to more objective measures for several reasons. First, it is difficult if not impossible to obtain objective performance measures from non-publicly traded firms. Secondly, self-reported measures are considered the easiest and most efficient way to gather data from a large number of TMT executives. Finally, studies have shown that self-reported and objective measures are highly correlated (Cagwin and Bouwman 2002; Schaffer and Steiners 2004).

Common method bias is another potential problem with survey data. Doty and Glick (1998) define common method bias as the "magnitude of the discrepancies between the observed and the true relationships between constructs that result from common method variance" (p. 376). Method variance occurs when the measurement approach used introduces systematic error variance into the measure rather than the construct of interest (Campbell and Fiske 1959; Cronbach and Meehl 1955). For example, common method variance may occur when a survey collects both the independent and dependent variable data from a single source (e.g., self-reported data). Method variance, if present, is a concern as it may bias empirical results and can thus threaten the validity of the study conclusions.

As this study proposes the use of self-reported data, it will include a supplemental test for common method bias following Williams, Edwards, and Vandenberg (2003) and Podsakoff, MacKenzie, Lee, and Podsakoff (2003). In this

approach, a method effect latent variable is added to the structural model for each indicator variable. Evidence of method variance can then be determined by (1) comparing this revised model with an alternative model in which all the method factor loadings are set to zero, (2) examining the statistical significance of the method factor loadings, (3) examining the percent of indicator variance that is method based (this is obtained by taking the square of the completely standardized method factor loadings), and (4) by comparing the results of the proposed model with and without the method factor loadings to determine the potential for method bias (Williams et al. 2003).

Conceptual Framework

This study conjectures that successful assimilation of ERP systems and subsequent superior firm performance depends on an organizations ability to successfully implement and fully utilize the system. The study investigates the effect of two types of organizational capabilities on assimilation and firm performance: IT management knowledge and IT management experience. The appropriate variables to be measured were identified through a comprehensive literature review. Existing validated measures were used; however, some adaptations were made to make the constructs relate more closely to the topic in this study.

The research model is shown in Figure 1. IT knowledge and experience measures are adapted using a framework developed by Bassellier et al. (2003) and Armstrong and Sambamurthy (1999). IT assimilation and two control variables, absorptive capacity and organizational compatibility, are measured using a framework

developed by Liang et al. (2007). Performance measures are adapted from Ifinedo and Nahar (2006) and Armstrong and Sambamurthy (1999).

[Insert Figure 1 about here]

Operationalization of Variables

Assimilation (Dependent Variable)

Drawing on the resource based theory (RBV) of the firm; the present study argues that a firm's IT knowledge is a key component necessary for successful ERP assimilation. Few studies have been published examining ERP assimilation with the exception of Liang et al. (2007). Liang et al. (2007), examines the effects of external institutional factors on ERP assimilation. The present study argues that the full potential of IT applications will not be fully realized unless they are extensively assimilated into the firm. Adapting a model developed by Massetti and Zmud (1996), the present study measures IT assimilation based on a three-item scale including volume, diversity, and depth. Volume is measured as the percentage of the firm's business processes that are using the ERP system. Diversity determines the number of functional areas in the firm that are automated using the ERP system. Depth measures the level at which the ERP system is being used for each functional area identified.

Performance (Dependent Variable)

In the present study, performance is measured using both operational and financial self-reported variables. Although there are concerns relating to self-reported and perceptual measures of performance, extant research, conducted on both private and public firms, provides evidence of a high correlation between perceptual and objective

measures at the firm level (Venkatraman and Ramanujam 1987; Dess and Robinson 1984).

Organizational impact, which measures ERP performance using an eight-item scale, is adapted for use in the current study (Ifinedo and Nahar 2006). This performance measure assesses the ERP systems' ability to reduce organizational costs, improve overall productivity, enable e-business or e-commerce, provide a competitive advantage, increase customer service and satisfaction, facilitate business process change, support decision making, and provide better use of organizational data resources. The Cronbach's alpha reported by Ifinedo and Nahar (2006) for this measure was 0.867.

Following Armstrong and Sambamurthy (1999), the present study adopts two additional performance measures. The first measure evaluates a firms' performance for each ERP module in relation to other competing firms in the same industry. The measure uses a 10 point Likert-type scale where 10 suggests that the respondents' firm is "most successful" in applying their ERP system. The second measure assesses ERPs based on specific business strategies in relation to other competing firms in the same industry. The respondents are asked to rate their firms performance based on eight items including: being a low-cost producer, having manufacturing/operations flexibility, enhancing supplier linkages, enhancing customer linkages, providing value-added services, enhancing existing products and services, creating new products and services, and entering new markets. Each of these items, although originally designed to test IT

in general, are also applicable to ERP systems as each of these eight items can be interpreted as relative outcomes from ERP implementations.

IT Knowledge and IT Experience (Independent Variables)

Bassellier et al. (2003) offer a framework for investigating the role of IT knowledge and IT experience of business managers in association with their intentions to champion IT in their organizations. The framework describes the IT competence of business managers in two dimensions: IT knowledge and IT experience. The reliability coefficients of these constructs as reported by Bassellier et al. (2003) for each sub-dimension of IT knowledge and for each sub-dimension of IT experience are greater than 0.80 and 0.90, respectively.

In the first dimension, questions relating to IT knowledge are used to assess the TMTs' knowledge in the areas of technology, applications, systems development, management of IT, and access to IT knowledge. Four applications, which were found to be important predictors of IT knowledge by Armstrong and Sambamurthy (1999), are added to the knowledge of technologies construct. These technologies include computer aided software technology (CASE), relational database management systems, object oriented database, and graphical user interface. Finally, knowledge of open-source software is added to the knowledge of applications construct to verify whether respondents are familiar with this new and emerging IT.

In the second dimension, questions relating to IT experience are used to assess the TMTs' IT experience based on their level of involvement with IT projects and on their level of involvement with the management of IT.

Absorptive Capacity (Control Variable)

Absorptive capacity refers to a firm's ability to recognize the value of external information, the ability to assimilate that new knowledge, and then apply it to commercial ends (Cohen and Levinthal 1990). Absorptive capacity is firm- rather than individual-specific. Based on RBV theory, absorptive capacity is the ability of a firm to acquire and apply prior external knowledge to enhance a firm's innovativeness and to facilitate the assimilation of *new* knowledge in the firm. Absorptive capacity, based on RBV theory, is a dynamic capability[12] that can provide a firm with a sustained competitive advantage (Narasimhan, Rajiv, and Dutta 2006).

Acquiring absorptive capacity involves the ability of a firm to access external knowledge and then transform, implement, and exploit that new knowledge into the firm in order to enhance its core competencies. At the firm level, the effect of prior related knowledge on newly adopted technology can enhance the firm's ability to assimilate that technology into the firm (Wang, Teo, Wei, Sia, and Lee 2003). Factors such as technical knowledge, training, and system support can be used to measure a firm's absorptive capacity.

Following Liang et al. (2007), the present study includes absorptive capacity as a control variable to account for firm differences attributable to prior organizational knowledge related to ERP. In the context of this study, absorptive capacity measures a firm's readiness for ERP assimilation. Specifically, absorptive capacity measures

[12] In the context of this study, absorptive capacity is considered a dynamic capability in that, when present, a firm is thought to possess a unique and rare resource. This unique resource is the ability of a firm to use prior external knowledge to enhance its ability to absorb or assimilate new technology (i.e., ERP) into the firm.

employee's prior knowledge of computer applications, knowledge of ERP technical and application support, and knowledge relating to training opportunities related to ERP.

Organizational Compatibility (Control Variable)

When a firm adopts complex technologies such as an ERP, it is important to understand its impact on all aspects of the organization including factors relating to organizational compatibility. Organizational compatibility refers to the degree to which a technological innovation is perceived as being consistent with a firm's operating practices, beliefs and values, past experiences, and needs (Rogers 1995). Depending on the level of business process change required as a result of an ERP adoption, significant workplace disruptions may occur. Therefore, the greater the fit among the adopted ERP system and the firm's organizational compatibility, the higher likelihood that workplace disruptions will be minimized. Thus, the more compatible the ERP system is with a firm's existing beliefs and work practices, the higher the likelihood of successful ERP assimilation.

As fit between implemented ERP systems and organizational compatibility may differ between firms, the proposed study measures organizational compatibility for each firm and uses it as a control variable. Following Liang et al. (2007), organizational compatibility is measured based on a three-item scale. The scale assesses compatibility in terms of the perceived change in organizational values, norms, and culture imposed by the adopted ERP system. It also assesses compatibility in terms of the perceived impact on both productivity and workplace disruptions caused by the adopted ERP system.

Data Analysis

Structural equation modeling (SEM) was used to assess the hypothesized model using data obtained from the sample firms. SEM offers several advantages compared to the more commonly used statistical methods of multiple regression and path analysis. SEM takes into account error variances associated with multi-item constructs. It allows the researcher to consider many relationships within a single analysis. It provides the ability for testing overall models rather than coefficients individually. It has to ability to test models with multiple dependents. Finally, it provides the researcher with several measures to assess model fit (Kline 2005).

SEM incorporates both path analysis and factor analysis. It is viewed as a confirmatory rather than exploratory procedure. This implies that SEM is used to test theory via a proposed model rather than being used to develop theory. SEM is confirmatory in nature when an *a priori* model is tested against actual data to see if it is consistent with the structural model. Variables used in SEM include latent variables and observed variables. Latent variables (also referred to as constructs or factors) are not directly observable or measurable. They are indirectly observed or inferred from measured variables such as survey questions. Observed variables (also referred to as indicator or manifest variables) are variables that can be directly observed and are therefore measurable. Observed variables are used to define latent constructs (Burnette and Williams 2005).

As suggested by Schumacker and Lomax (2004), a two-stage process was used to assess both the measurement and structural models proposed in the study. In the first

stage, a model is developed based on theory. Next, each latent variable is modeled as a separate measurement model whereby the measurement model relates the observed variables to their respective latent variable. In this study, the latent variables are technology, applications, systems development, management, access to knowledge, experience in IT projects and IT management, IT knowledge, IT experience, ERP assimilation, and firm performance. The measurement model is then validated by establishing that the observed variables are reasonable measures of each latent variable. Validation of the measurement model addresses both convergent[13] and discriminant[14] validity.

The second stage involves constructing the structural model by specifying specific causal relationships between the latent variables. These causal relationships are hypothesized based on *a priori* theory. Structural equation modeling is designed to estimate the strength and direction of each hypothesized path as specified in the model. Provided the measurement model has both convergent and discriminant validity, the test of the structural model provides an assessment of the structural model in terms of nomological[15] validity (Anderson and Gerbing 1988; Burnette and Williams 2005). In the proposed model, the latent variables, IT knowledge and IT experience, are hypothesized to influence ERP assimilation and hence, ERP assimilation is hypothesized to influence firm performance.

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[13] Convergent validity is the degree to which measures in a construct that *should be* theoretically similar to each other are in fact similar to each other.
[14] Discriminant validity is the degree to which measures in a construct that *should not* be theoretically similar to each other are in fact not similar to each other.
[15] Nomological validity is the degree to which a construct behaves as it should within a system of related constructs.

The structural equation modeling statistical package, LISREL (Joreskog and Sorbom 2005), was used to test the relationships hypothesized by the research model. LISREL allows for an *a priori* approach where confirmatory factor analysis is performed on a specified measurement model. SEM is considered confirmatory as it requires the researcher to develop the structural model through careful consideration of relevant theory. Next, testing of the relationships in the model was performed to see if it is supported by the data (Kline 2005).

Several of the previous studies on IT assimilation have used the PLS approach which differs from SEM in that PLS is a limited-information estimation approach rather than a full-information estimation approach. Advantages of PLS over SEM include the ability to work with smaller sample sizes, no requirement for normally distributed multivariate data, and the ability to estimate parameters so as to maximize the variance explained. However, because PLS is considered a limited-information approach, parameter estimates are not considered to be as efficient as the full-information estimates provided by SEM. Unlike SEM, PLS has no overall test for model fit (Chin 1995; Anderson and Gerbing 1988). Therefore, for the proposed study, a full-information approach (i.e., LISREL) will be used to test the hypothesized model.

Model fit will be assessed using an adequate selection of fit indices as suggested by McDonald and Ho (2002) and Kline (2005). Fit indices to be evaluated include: the model chi-square (χ^2), the Root Mean Square Error of approximation (RMSEA), the Bentler Comparative Fit Index (CFI), the Bentler-Bonnet Non-Normed Fit Index (NNFI), and the Adjusted Goodness of Fit Index (AGFI).

The model chi-square fit statistic is the most common fit statistic and can be used to test the overall significance of the proposed model. The statistic is calculated as the difference between the actual sample covariance matrix (based on actual data collected from the sample) and the predicted covariance matrix.[16] Small values of the chi-square statistic indicates small residuals and thus a relatively good fit (Williams, Ford, and Nguyen 2002) The chi-square test is considered a "badness-of-fit" test, as a significant result (i.e., statistical significance < 0.05) means that the hypothesized model's covariance structure is significantly different from the actual data (i.e., the higher the chi-square value, the worse the model's relationship with the actual data). This suggests that the chi-square test *should not* be significant if there is a good model fit (Kline 2005).

The RMSEA corrects for model complexity by including degrees of freedom in the denominator. RMSEA is suggested to be a popular measure of fit because it does not require comparison with a null model and it is less affected by sample size (Schumacker and Lomax 2004). RMSEA is considered a descriptive measure of overall model fit and lower values indicate a better fit. Hu and Bentler (1999) suggests that the cut off used to determine a good model fit for the RMSEA is less than or equal to 0.06. Williams et al. (2002) suggest that a value of 0.05 indicates a very good fit whereas a value of 0.08 suggests a good fit.

The CFI is an incremental fit index. CFI compares the existing model fit with a null model which assumes that the latent variables in the model are uncorrelated. CFI

[16] SEM uses the maximum likelihood method which is an estimation process used to generate parameter values that best reproduces the observed variances and covariances.

penalizes for sample size and its value varies between 0.0 and 1.0. CFI values close to 1.0 represent a very good fit (Kline 2005). The suggested threshold value for the CFI is 0.95 or above (Hu and Bentler 1999).

The NNFI is also an incremental fit index. Similar to the RMSEA, the NNFI also corrects for model complexity and is less affected by sample size. The threshold value suggesting a good fit for the NNFI is 0.95 or above (Hu and Bentler 1999). Finally, the AGFI is an absolute fit index and is analogous to the R^2 (Kline 2005). The cutoff value suggesting a good fit is 0.95 (Schumacker and Lomax 2004).

In addition to the fit measures addressed above, Cronbach's α was computed for all measurement models. Cronbach's α is a commonly used measure testing the extent to which multiple indicators for a latent variable belong together (i.e., construct validity). The measure varies between 0.0 and 1.0. A general rule of thumb suggests that indicators should have a Cronbach's alpha of 0.70 or above in order to be considered reliable (Kline 2005). Tables 7 and 8 provides details of the model fit for all measurement models based on the fit indices specified above.

Chapter 5

Empirical Results and Analyses

Descriptive Statistics

Sample demographics show that of the respondents, ten percent were Chief Executive Officers, nineteen percent were Chief Financial Officers, twelve percent were Chief Operating Officers, thirty seven percent were Chief Information Officers and twenty four percent were other members of the TMT. Of these respondents, seventy six percent were male. The majority of the respondents had a bachelor's degree (fifty one percent), fifteen percent a master's degree and twenty one percent an associate's degree. Additional demographics, as shown in Table 5, show that the mean age (AGE) of the participant is 47.56 and the mean number of years spent with the firm (FIRMYRS) is 12.72.

Table 5 presents the mean values for all measured variables in this study. Five-point Likert scales were used to measure the IT experience (ITEXP) and IT knowledge (ITKNOW) variables (e.g., anchor points ranged from very low to very high). Both five-point and ten-point Likert scales were used to assess the performance (PERF) variables. A partial disaggregation parceling technique (this approach is described along with the measurement model below) was used resulting in three parcels each for the ITEXP, ITKNOW and PERF variables. An examination of Table 5 reveals that the mean values for the ITEXP, ITKNOW, and PERF variables are all above the scale medians. Volume (VOL), diversity (DIV), and depth (DEP) are measured on a scale of

0-100%. As shown in Table 5, the mean values for VOL, DIV, and DEP are 78%, 78%, and 65% respectively.

Table 5 also presents the mean values for the five control variables included in the study. Firm revenue (FirmRev) is measured using a range scale of one to six. The mean value for FirmRev is 2.32 suggesting that the average revenue for the participating firms is in the range of $51-$100 million. Number of employees (Empl) is measured using a range scale of one to seven. The mean value for Empl is 2.69 suggesting that the average number of employees is in the range of 101-200. Time since ERP implementation (Time) is measured in years and the mean age of the COSES is 6.12 years. Five-point Likert scales were used to measure the absorptive capacity (ABSCAP) and organizational compatibility (ORGCOM) variables (e.g., anchor points ranged from strongly disagree to strongly agree). An examination of Table 5 reveals that the mean values for the ABSCAP and ORGCOM variables are all above the scale medians.

[Insert Table 5 about here]

Cronbach's alpha is an index of reliability associated with the variation accounted for by the true score of the underlying construct (i.e., the hypothetical variable being measured) (Cronbach 1951). Alpha coefficients range from 0.00 to 1.00, the higher the score, the more reliable the construct. Nunnaly (1978) suggests that 0.70 is an acceptable reliability coefficient. Each of the measures used in this study has a Cronbach's alpha reliability of greater than 0.753 as shown on the diagonal of Table 6. Five of the measures have Cronbach's alpha scores above 0.84.

[Insert Table 6 about here]

A correlation matrix for each of the latent variables is presented in Table 6. The correlation matrix shows significant positive correlations in the direction expected for the PERF, ASSIM, ITEXP and ITKNOW variables. For the control variables, there is a significant and positive correlation between ABSCAP and FirmRev with PERF and ASSIM. ORGCOM is reverse scored therefore there is a significant and negative correlation with PERF and ASSIM as expected. For both Time and Empl there is no significant correlation with PERF and ASSIM.

Sample Size

Kline (2005) suggests that there is no simple answer to the question as to how large a sample needs to be to use SEM. He suggests that a sample size less than 100 is considered small, between 100 and 200 medium, and greater than 200 is large. According to Hair, Anderson, Tatham, and Black (1998) the minimum sample size required to provide valid fit indices is between 100 and 200. Bentler and Chou (1987) suggest a minimum of a 5:1 ratio of observations to variables for normal and elliptical distributions and a 10:1 ratio for other distributions. In the current study there are 16 indicator variables with a sample size of 164, thereby meeting the thresholds proposed by Kline (2005), Anderson et al. (1998), and Bentler and Chou (1987).

Response Rate

A total of 1,044 surveys were emailed to potential respondents. Of those, 429 were returned as undeliverable,[17] 24 were eliminated as they had either just implemented the ERP system or had stopped using the system entirely, and 23 were eliminated as the surveys were largely incomplete resulting in a sample of 568 usable responses. A total of 164 surveys were completed between the dates of May 13, 2008 and June 27, 2008 for a twenty nine percent response rate.

Response Bias

To test for response bias between early and late respondents, a comparison of the variances and means on all measured variables was performed. The assumption for each test is that the late respondents will have similar characteristics as the early respondents. Using the Levene's Test for Equality of Variances[18], the study found that the variances for each of the measured variables in the two groups were roughly equal (i.e., there is homogeneity of variances). Next, the means of the measured variables for the two groups were compared using a t-test. The results of the t-test for each measured variable show that there were no significant differences between the means for these two groups, suggesting our results are not biased by non-responses.

[17] This large undeliverable number is not surprising as the vendor database used included email addresses for prospective ERP customers as well as active customers.

[18] Levene's test is similar to that of a t-test in that it tests the hypothesis that the variances in the two groups are equal (if Levene's test is non-significant then the null hypothesis is accepted suggesting that the differences between the variances is zero; that is the difference between the variances are roughly equal).

Analytical Model and Results

Measurement Model

Structural equation modeling is an analytic method which allows a researcher to examine patterns of relationships among constructs. When multi-item scales are used, there are several options for linking latent variables with their indicators. Options include linking each indicator variable directly to its respective latent variable, creating composite measures, or parceling.[19] Advantages of using parcels as indicators of constructs include higher reliability than single items, reduction in the number of indicators in a model, and the ability to correct for non-normal data (Coffman and MacCallum 2005).[20] Other advantages include higher communality, less item-idiosyncratic influence, a greater likelihood of achieving a proper model solution and a better model fit (Meade and Kroustalis 2006). Parceling has been shown to help overcome some of the disadvantages of using items as measures of constructs. Noted disadvantages of using items as measures include: lower reliability and communality; increased chance for correlations among uniqueness estimates; and obviating the need for a large sample size resulting from estimating a larger number of parameters (Williams and O'Boyle 2008).

[19] Parceling is a process which takes individual items and aggregates them into subscales prior to analysis.

[20] Coffman and MacCallum (2005) suggest that parceling provides the researcher with the opportunity to use more indicators thus providing a better representation of the construct and thereby increasing the reliability of the parcel. In addition, the authors suggest that parceling can help to create more normally distributed measures thus helping to overcome the problems associated with estimates of fit measures and standard errors caused by items violating multivariate normality assumption.

In this study, the *factorial algorithm* parceling approach developed by Rogers and Schmitt (2004) was used to create three parcels[21] each for the ITKNOW, ITEXP, ASSIM and PERF variables. This approach is considered a partial disaggregation method whereby parcels are created that result in measures that are "equally balanced both in terms of their difficulty and discrimination" (Williams and O'Boyle 2008, p. 5).

Following the Schumacker and Lomax (2004) two stage process (described in Chapter 4, Data Analysis section), the measurement model was first validated using confirmatory factor analysis (CFA). Although the multi-item scales used in this study had demonstrated validity and reliability in prior research (Bassellier et al. 2003; Liang et al. 2007; Raymond 2005), the method used to link the latent variables to their indicators was changed. Therefore, CFA was conducted on the parceled items that comprised the ITEXP, ITKNOW, ASSIM and PERF variables in order to ensure construct validity. In addition, CFA was also conducted on the ABSCAP and ORGCOM variables.

Construct validity seeks to confirm that the items in a measure adequately represent the underlying construct. Construct validity can divided into convergent and divergent validity. Convergent validity tests whether items in a measure that should be related are in fact related and divergent validity tests for the lack of a relation in items that should not be related. Using LISREL, construct validity is assessed utilizing the test statistic calculated with the Maximum Likelihood method for each of the latent indicators (this statistic is found in the LISREL output under LISREL Estimates).

[21] Kline (2005) recommends three indicator variables for each latent variable, particularly if sample size is small.

Factor loadings that are statistically significant (for this study significance is determined at the 0.05 level; i.e., test statistic ≥ 1.96) would be an indication of construct validity. Based on the test statistics provided in the LISREL output, the construct validity for each of the eight latent variables meets or exceeds the 0.05 threshold. In addition, examination of the correlations between the indicator variables can also help to determine both convergent and divergent validity. Review of the correlations matrix between the indicator variables provides support for both convergent and divergent validity (see Table 6).

As suggested by McDonald and Ho (2002) and Kline (2005), along with the chi-square fit statistic, four criteria were used to assess the overall fit of the measurement model. These criteria include (1) the Root Mean Square Error of Approximation (RMSEA), (2) the comparative fit index (CFI), (3) the non-normed fit index (NNFI) and (4) the adjusted goodness of fit index (AGFI).

A structural equation modeling technique (LISREL 8.72) was used to estimate the measurement model. The results indicate a chi-square test statistic of 151.41. The RMSEA corrects for model complexity by including degrees of freedom in the denominator. Hu and Bentler (1999) suggest the cutoff value used to determine a good model fit is 0.06 and Williams et al. (2002) indicate a value of 0.08. The RMSEA reported for the measurement model is 0.061 suggesting a good model fit. The CFI and the NNFI are incremental fit indices that compare the existing model with a null model which assumes that the latent variables in the model are uncorrelated. Hu and Bentler (1999) suggest a threshold value of 0.95. The CFI and NNFI reported for the

measurement model is 0.97 and 0.97, respectively. The AGFI is analogous to the R^2. The cutoff value suggesting good model fit is 0.95 (Schumacker and Lomax 2004). The AGFI reported for the measurement model is 0.85. All of the fit indices except for the AGFI met the acceptable thresholds for a reasonable fitting model thus suggesting that the measurement model possesses an acceptable fit. Table 7 provides the results of the CFA.

[Insert Table 7 about here]

Structural Model

The second stage of the Schumacker and Lomax (2004) process involves testing the structural model prior to testing the hypotheses. In this study, the proposed structural model (see Figure 1) is examined using LISREL 8.72. The maximum likelihood method was used to estimate all parameters and fit indices. SEM fit indices measure the extent to which the covariance matrix derived from the hypothesized model is different from the covariance matrix derived from the sample. The fit indices from the structural model (with and without the control variables) are reported in Table 8. Figure 2 and 3 show the details on the path coefficients for both models.

[Insert Table 8 about here]

[Insert Figure 2 about here]

[Insert Figure 3 about here]

Based on the results of the SEM fit indices, both models provide a good fit. The RMSEA for each model is below the recommended cut off of 0.08 (Williams et al. 2002) and the CFI and NNFI are greater than 0.90. Only the AGFI did not meet the

generally acceptable fit standard of 0.95. Overall, the hypothesized structural model provides and acceptable fit for the data.[22]

Hypothesized Testing

The SEM path results are shown in Figures 2 and 3. The first model tests the relation between ITKNOW and ITEXP with ASSIM and PERF without control variables. Hypothesis 1a proposes that high levels of TMT IT knowledge will positively influence ERP assimilation. As shown in Figure 2, the coefficient for the path from ITKNOW to ASSIM is positive and non-significant (0.10, p=0.3159) which does not support hypothesis H1a. Hypothesis 1b proposes that high levels of IT experience will positively influence ERP assimilation. The coefficient for the path from ITEXP to ASSIM is positive and significant (0.22, $p \leq 0.05$) which supports hypothesis H1b. Hypothesis 2 proposes that high levels of ERP assimilation will result in high levels of operational performance. The coefficient for the path from ASSIM to PERF is positive and significant (0.51, $p \leq 0.01$) supporting hypothesis 2.

The SEM path results for the second model which includes the five control variables are depicted in Figure 3. With the exception of ABSCAP, all control variable paths are non-significant. In addition, all control variables do not affect the significance of the path weights among the major constructs in the model. As shown in Figure 3, the coefficient for the path from ITKNOW to ASSIM is positive and non-significant (0.01, p=0.3159) which does not support hypothesis H1a. Hypothesis 1b proposes that high

[22] An alternative model was tested which included direct paths from the ITKNOW and ITEXP variables to PERF. Overall, the results of the chi-square difference test show that the hypothesized model is a better fitting model.

levels of IT experience will positively influence ERP assimilation. The coefficient for the path from ITEXP to ASSIM is positive and significant (0.24, $p \leq 0.05$) which supports hypothesis H1b. Hypothesis 2 proposes that high levels of ERP assimilation will result in high levels of operational performance. The coefficient for the path from ASSIM to PERF is positive and significant (0.52, $p \leq 0.01$) supporting hypothesis 2.

Hypothesis 3 proposes that higher levels of ERP customization (MOD) will lead to higher levels of operational performance. In a supplemental analysis, the study finds a positive but non-significant path between MOD and PERF (0.02, p=0.1179). An alternative model is tested whereby ASSIM mediates the relation between MOD and PERF. The results show a positive and significant path between MOD and ASSIM (0.19, $p \leq 0.05$) and a positive and significant path between ASSIM and PERF (0.49, $p \leq 0.01$). The RMSEA for this model is 0.04 with a CFI of 0.99, NNFI of 0.99, and an AGFI of 0.94. The fit indices from the structural model (with and without the control variables) are reported in Table 9.

[Insert Table 9 about here]

Hypothesis 4 proposes that the higher the level of ERP customization, the higher the TMT will perceive its competitive advantage will be. On average, modification to COSES (MOD) modules was approximately 21% and the average rating of the impact of COSES on a firm's competitive advantage was 3.64 (on a 5-point scale where 1 is no impact and 5 is significant impact). Linear regression analysis was performed to test this hypothesis and the results show that the data do not support this hypothesis.

[Insert Table 10 about here]

Supplemental Analysis

In order to control for the potential for common method bias, the following techniques as recommended by Podsakoff et al. (2003) were incorporated into the survey instrument: (1) allowing respondents' answers to be anonymous, (2) counterbalancing the question order, and (3) improving scale items by using validated scales (this step included defining ambiguous terms, keeping questions simple, and using different scale endpoints). In addition, based on the recommendation of Williams et al. (2003) and Podsakoff et al. (2003), Harman's single factor test was also used to test for common method bias. This test involved performing exploratory factor analysis on all indicator variables using unrotated principal components factor analysis and principal component analysis with varimax rotation to determine the number of factors that are necessary to account for the variance in the variables. If a substantial amount of common method variance is present, either a single factor will emerge from factor analysis or one general factor will account for a majority of the covariance among variables. The unrotated principal component analysis and principal component with varimax rotation revealed the presence of four distinct factors with eigenvalue greater than1.0, rather than a single factor which is consistent with the research model. The four factors together represented eighty eight percent of the total variance and the variance explained for each of the four factors was 43.109, 22.588, 10.082, and 8.883 percent (unrotated) and 24.237, 23.332, 21,554 and 15.538 percent (rotated). Moreover, the confirmatory factor analysis showed that the single-factor model did not fit the data well (RMSEA = 0.362, CFI = 0.450, NNFI = 0.330, and AGFI = 0.200). Following,

Williams et al. (2003), a method factor latent variable was added to the model. Comparing the results of the proposed model with and without the method factor loading variable using a chi-square difference test reveal no significant difference between the two models. In addition, examination of the reveal non-significant method factor loadings.While the results of these analyses do not preclude the possibility of common method bias, they do suggest that common method variance is not of great concern and thus unlikely to confound the interpretations of the results.

Chapter 6

Summary and Conclusions

Summary

The purpose of the present study was to investigate the role of firms' TMT IT knowledge and IT experience in relation to ERP assimilation and firm performance. The motivation for this inquiry was (1) the increase in the use of ERP by small and medium enterprises and their importance to the U.S. economy, (2) the dearth of published studies on SMEs using ERPs, (3) the drastically changed format of ERP software and (4) the importance of the TMT to small and medium sized enterprises. Accordingly, the TMT's IT knowledge and experience for small and medium sized enterprises were identified as primary variables that could be used to explain the variability in the level of ERP assimilation and firm performance across similar organizations.

This study supports the hypothesis that a firm's TMT IT experience has a positive and significant impact on ERP assimilation and firm performance. For SMEs that rely on only one or two key players for decision making, it is vital that the TMT members of these firms play an active role in both the development of IT projects, such as ERP, and in the management of those projects. In relation to a firm's TMT IT knowledge and assimilation, the study finds a positive path coefficient, however the path coefficient is non-significant. The study finds instead a positive and significant relation between the control variable absorptive capacity and assimilation. Boynton et al. (1994) suggest that absorptive capacity is a knowledge function encompassing both

managerial IT-related and business-related knowledge. That is, absorptive capacity not only represents the acquisition of IT knowledge but also the organizations ability to exploit such knowledge[23]. Therefore, a likely explanation for the non-significant finding between IT knowledge and assimilation may be that the absorptive capacity variable is a better measure of a firms overall IT knowledge. That is absorptive capacity is a reflection of a firm's ability to successfully develop technical ERP support and training programs thus ensuring transfer of knowledge across all units in the organization.. The data shows that TMT participants believe their employees had extensive computing experience prior to implementing the ERP system, they knew who to turn to for ERP technical support and problem solving, and that the firm provided adequate ERP training opportunities for the users.

Similar to Raymond (2005), the study finds a positive and significant path coefficient between ERP assimilation and firm performance in support of hypothesis H2. This result suggests that firms that are more proficient in their ability to "internalize" and "master" their ERP systems, are able to attain higher levels of operational performance. Thus, with the availability of lower cost, more innovative ERP systems such as COSES, the study demonstrates that similar to large enterprises, SMEs also benefit from such advanced technology.

COSES are deemed distinct as they provide firms with a resource that allows them to maintain their unique business processes. For SMEs, this is particularly important as unlike the generic, "best practices" ERP systems, COSES provide SME

[23] Absorptive capacity depends not only on the ability of a firm to acquire new knowledge, but also depends on the transfer of such knowledge across all units of that organization.

firms the opportunity to stay agile and flexible; two key components necessary for these firms to stay competitive. Hypothesis H3 assesses whether there is a significant relation between a firms customization of COSES (MOD variable) and its operational performance. Instead of a direct relation to operational performance, the study finds that assimilation mediates the relation between MOD and operational performance. A positive and significant path coefficient of 0.19 ($p \leq 0.05$) is found between MOD and ASSIM and a positive and significant path coefficient of 0.49 ($p \leq 0.01$) is found between ASSIM and PERF. This is not surprising as COSES permits firms to leverage their ERP systems to create a unique resource that properly aligns the technology with its organizational processes. The more aligned the ERP system is with the firm's business processes, the greater the opportunity for the firm to properly assimilate the technology. As the results indicate, firms that have customized their COSES to fit their unique business processes have achieved higher levels of assimilation and in turn higher levels of firm performance.

The fourth hypothesis is not supported. This hypothesis suggests that there is a relation between higher levels of COSES customization and a firm's perceived competitive advantage. A likely explanation for this finding is that firms will only have a competitive advantage over other firms that do not have ERP systems. In support of this explanation, Hunton et al. (2003) suggest that any advantage of SME firms adopting ERP systems is likely to dissipate in the future as ERP systems become more affordable.

Theoretical Contributions

The role of ERP systems in large enterprises adopting systems from large vendors such as SAP is well established. Much has been published on the selection, adoption, and implementation stages of ERP systems by large enterprises. What is less understood is the impact of ERP systems on the SME market and on emerging types of ERP systems such as COSES. The focus of this study, on the post-implementation stage of ERP systems (i.e., the assimilation stage) used by SMEs, signifies its contribution to the theory of both IT assimilation and the RBV of the firm. This study extends the findings of Raymond (2005) and Liang et al. (2007) by investigating the assimilation phase of ERP systems on SME firms.

Managerial Implications

The findings of this study offer guidance to management, IT practitioners, and ERP vendors alike. The experience of the TMT and the absorptive capacity of the firm highlight the significant role that both play in the ability of the firm to assimilate an ERP system. As ERP systems become mainstream applications for SME, it is crucial that management understand their influence in the successful assimilation of such technology. TMT members must also recognize the importance of staying current with technology by actively participating in industry, vendor, and educational events. IT practitioners and ERP vendors need to be aware of the different needs of SMEs that are likely to adopt ERP systems. SMEs require systems that allow them to be agile and flexible. SME firms will not benefit from traditional ERP systems which are inflexible

and rigid. Thus, IT practitioners need to be aware of new and innovative ERP technologies such as COSES and the benefits that can be derived from them particularly for SMEs. In addition, as large ERP vendors attempt to enter into the SME market; these vendors must recognize the need for products that are better suited to the SME market in terms of affordability, flexibility, and efficiency.

Limitations and Potential for Future Research

This study has several limitations. First, the data was collected from clients of a single COSES vendor and therefore does not represent a random sample. An interesting follow up to this study would be to collect data from a random sample of SME firms that have implemented both traditional ERP systems and unique ERP systems. In such a study, a comparison of the impact on assimilation based on various types of ERP systems could be assessed. Secondly, common to survey studies, the nature of the sample and self-reported measures dictate that one should take care in generalizing the results. Future research could address this limitation by collecting more objective measures of operational performance and thus strengthen the research findings on the impact of ERP assimilation on firm performance. Thirdly, there are many factors other than those included in this study that can impact assimilation and operational performance of SMEs adopting ERP systems. Examples include a firm's technological infrastructure and/or any external institutional pressures to implement such systems.[24] Future research could include such variables examining the relation between a firm's

[24] Pressure to adopt ERP systems can be imposed directly by regulatory agencies or indirectly through industry associations and are likely to influence a firm's ability to assimilate such technology.

technological infrastructure and/or any institutional pressures and its impact on assimilation and performance.

Conclusions

ERP systems are likely to take on added importance for SMEs, particularly as new, affordable, and innovative systems become available. As SMEs play an important role in the U.S. economy and as these firms embrace ERP technology, there is a need to better understand the way in which such systems are assimilated into their business. As SMEs may have less of a chance for recovering from a failed ERP attempt than large enterprises with more resources, it is important for SMEs to adopt ERP systems that allow them to remain flexible and adaptable to change. In SMEs, the TMT members must have extensive knowledge and experience with IT in order to evaluate the appropriateness of adopting technology solutions such as ERP. In addition, the TMT is instrumental in ensuring the assimilation of any new technology into the firm. Given the dearth of empirical studies on emerging types of ERP systems and on SMEs in particular, this study contributes to the literature by providing a better understanding of the relationship between a firm's TMT IT experience and knowledge and its impact on assimilation and firm performance. In addition to the impact of the TMT on assimilation and performance, added knowledge has also been gained on the role in which commercial open source ERP systems play in improving firm performance for SMEs.

Analyses based on 164 SME firms that have adopted COSES largely support the hypothesized relationships identified in this study. This research contributes to the ERP literature by focusing on the neglected SME market, on the assimilation stage of IT, and

on the impact of new and innovative types of ERP systems. It confirms that SME's benefit, through higher levels of IT assimilation and performance, from having a TMT that has experience with and is knowledgeable about technology. It also highlights the importance of the TMT in facilitating IT assimilation. Finally, the results suggest that SMEs can benefit from adopting ERP systems such as COSES (i.e., higher levels of assimilation and higher levels of firm performance).

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Table 1
Empirical SME AND ERP Research

Author(s)	Method/Sample	Independent Variable	Dependent Variable/Findings
Benroider and Koch (2001)	Survey - 138 Austrian SME	Number of employees, turnover and industry	• Selection characteristics (e.g., size, structure of team) • Several variables differ between SMEs and large enterprises (e.g., team structure, information gathering)
Buonanno, Faverio, Pigni, Ravarini, Sciuto, and Tagliavini (2005)	Survey - 366 Italian firms	Business complexity measured based on size, diversification and divisionalization	• ERP adoption • Size good predictor of adoption whereas diversification and divisionalization are not
Huin (2004)	Case Study - 30 SME from South East Asia	Strategic and operational requirements (e.g., organization hierarchy, CEO involvement, production modes)	• ERP deployment • SME strategic and operational requirements differ significantly from large enterprises (e.g., CEO involvement))
Koh and Simpson (2007)	Survey - 120 UK firms	Business environmental factors (i.e., underlying causes of uncertainty on product late delivery)	• Delivery Uncertainty • Only few features of ERP were used to deal with change due to uncertainty
Olsen and Saetre (2007)	Case Study - case company producer of propeller blades	Proprietary vs. standard ERP system	• Competitive advantage – achieved through use of in-house developed system rather than standard ERP packages
Raymond (2005)	Survey - 118 Canadian SME firms	Operational critical success factors, environment, assimilation of advanced manufacturing technologies	• Operational performance - all 3 IV were significantly related to performance
Raymond and Uwizeyemungu (2007)	Survey - 356 Canadian manufacturing SMEs	Environment, organizational and technological context	• ERP adoption • Size good predictor of adoption whereas diversification and divisionalizaiton was not
Shin (2006)	Survey - 525 Korean SME firms	Tangible assets (IT and non IT), employment costs and dummy variables for ERP modules	• Firm performance • SCM and groupware positive association with performance
Vemuri and Palvia (2006)	Archival – medium sized public firms including 17 chemical or pharmaceutical firms	Firm specific factors and industry specific factors	• Performance measures (Inventories, COGS) ERP implementation did not improve operational efficiencies

Table 2
ERP Assimilation Research

Author(s)	Method/Sample	Independent Variable	Dependent Variable/Findings
Kouki, Pellerin, and Poulin (2007)	Case Study - 3 manufacturing firms	ERP attributes, IT expertise, top management championship, absorptive capacity, strategic alignment, user involvement, reward system, institutional pressures and vendor consultant support	• ERP assimilation (decision level supported by ERP and width of activities supported) • IT skills and competence, and top management championship were crucial
Liang, Saraf, Hu , and Xue (2007)	Survey - 77 Chinese firms	Institutional forces (mimetic, coercive and normative), top management (beliefs and participation)	• Enterprise systems assimilation (diversity, depth and volume) • Top management belief and participation mediates mimetic and coercive institutional forces • Normative institutional forces directly affect assimilation.
Papastathopoulou, Avlonitis, and Panagopoulos (2007)	Survey - IT managers from 500 Greek firms	ICT Characteristics (relative advantage, compatibility, cost, security), organization characteristics (formalization, commitment to change) and market characteristics (demand uncertainty, intensity of competition)	• Marketing and non-marketing related ICT diffusion (marketing, communication and financial effectiveness)
Raymond (2005)	Survey - 118 Canadian manufacturing firms	Operational critical success factors, environment, assimilation of advanced manufacturing technologies	• Operational performance (productivity, cost reduction, flexibility, quality and integration) • Firms more proficient in AMT achieve higher performance
Vluggen (2005)	Survey - 184 Dutch firms using SAP	External and internal environment, technological characteristics,	• ERP usage level • Relations found with characteristics from each IV

Table 3
ERP and Firm Performance

Authors	Data Period	Data Source	Sample Size	Research Questions	Performance Measure	Findings
Hendricks, Singhal, and Stratman (2007)	1991 - 1999	Business Wire, Dow Jones News Service, PR Newswire & Wall Street Journal	406 firms -186 ERP announcements	Does investing in ES (ERP, SCM and CRM) lead to financial performance improvements?	ROA, ROS & abnormal stock returns	• For ERP adopters find some improvement in profitability but not in stock returns
Hitt, Wu, and Zhou (2002)	1986 - 1998	SAP database of vendors, Compustat & Computer Intelligence	1,117 SAP implementations	Does implementation of SAP lead to financial, productivity and stock market improvements?	Labor productivity, ROA, inventory turnover, ROE, profit margin, asset turnover, DTE & Tobin q	• SAP adopters show improvements in performance ratios, productivity and market valuation but not ROE • Greater improvement during adoption than before or after
Hunton, Lippincott, and Reck (2003)	1990 - 1998	Lexis/Nexis, Newswire service reports	63 firms	Is the long-term financial performance of ERP adopters different from non-adopters?	ROA, ROS, asset turnover, ROI	• ROA, ROI & asset turnover greater for adopters • Interaction between size/health firm
Hunton, McEwen, and Wier (2002)	1995 - 1999	Experimental data – financial analysts	63 financial analysts	Does ERP announcement impact financial analysts forecasts?	Earnings forecast revision (pre-post announcement)	• Post announcement forecast were higher • Difference in abnormal returns between large/small unhealthy firms
Karimi, Somers, and Bhattacherjee (2007)	2002 - 2003	Harris Nationwide Manufacturing database	148 U.S. manufacturing firms	Do IS resources have effect on building ERP capabilities? What impact do ERPs have on BPO?	Operational efficiency, effectiveness & flexibility	• Relationship resources associated with BPO • Knowledge and infrastructure, no association

Table 3 (continued)
ERP and Firm Performance

Authors	Data Period	Data Source	Sample Size	Research Questions	Performance Measure	Findings
Matolcsy, Booth, and Wieder (2005)	1993 - 1999	SAP published client list	35 Australian & New Zealand firms	Does adoption of ERP improve performance?	Operation (inventory and fixed asset turnover), inbound/outbound logistics & overall performance	• Adoption of ERP leads to sustained operational efficiencies, improved liquidity & A/R management
Nicolaou, Stratopoulos, and Dehning (2003)	1990 - 1998	Lexis/Nexis, Newswire service reports, Global Disclosure database, Compustat	247 firms	Does adoption of ERP improve performance? Does choice of vendor, implementation goals or time impact performance?	ROA, ROI, ROS, operating income over sales, COGS/sales, SG&A, number of EE's/sales	• Adopting firms exhibit higher differential performance only after two years of continued use
Poston and Grabski (2001)	1992 - 1997	Public relations newswire & Compustat	50 firms	Does ERP implementation result in higher performance?	S&A, COGS, Revenue per number of EE's	• Number of EE's decreased; no effect from other measures
Shin (2006)	2000-2001	KIS-Value firm data	525 firms	Does enterprise application (EA) software improve SMEs productivity?	Labor, physical capital, and IT capital	• EA adoption rates and real benefits not closely related domestically • EA facilitating inter-firm relationship more effective • Easy to understand and long-standing EA more effective

Table 3 (continued)
ERP and Firm Performance

Authors	Data Period	Data Source	Sample Size	Research Questions	Performance Measure	Findings
Tsai, Fan, Leu, Chou, and Yang (2007)	n/a	Self-reported variables (survey_	45 firms	Is there a relationship between ERP implementation variables and performance improvements?	System and information quality, system use, user satisfaction, individual and organizational impact	• The factors that had the largest impact on performance was in-house developed ERP and implantation of all planned modules
Vemuri and Palvia (2006)	1993 - 2002	Success stories promoted by SAP	17 medium-sized chemical and pharmaceutical firms	Does the implementation of ERP in medium-sized chemical and pharmaceutical firms improve efficiency?	Inventory, cash & cash equivalent, COGS, operating income & SG&A	• ERP implementation did not improve operational efficiency • Operational measures worsened after implementation
Wieder, Booth, Matolcsy, and Ossimitz (2006)	2001	Australian Business Journal top 500 list & Connect4 database	102 Australian firms	Is there a difference between ERP adopters and non-adopters at the supply chain and firm level?	ROI, operating profits, sales growth rate & cost reduction	• No significant differences were found at the business process level or firm level
Wier, Hunton, and HassabElnaby (2007)	1992-1998	Lexis/Nexis and sample from Hayes, Hunton, and Reck (2001)	ERP firms (139), ERP & NFPI (40), and NFPI (85)	Will joint adoption of ERP and use of NFPI yield greater performance?	ROA and stock returns	• Firms that adopt ERP and use NFPIs have higher short-term and long-term performance as measured by ROA and stock returns

Table 4
Variable Labels and Definitions

Variable Type	Variable in Model	Variable Description	Variable Source
Indicators	ITEXP1 – ITEXP3	3 parceled variables calculated using 28 indicators based on the factorial algorithm method developed by Rogers and Schmitt (2004)	Survey questions relating to experience in both IT Projects and experience in the general management of IT
Indicators	ITKNOW1-ITKNOW3	3 parceled variables calculated using 8 indicators based on the factorial algorithm method developed by Rogers and Schmitt (2004)	Survey questions relating to knowledge of technologies, applications, systems development, management of IT and access to information
Indicators	PERF1 – PERF3	3 parceled variables calculated using 31 indicator based on the factorial algorithm method developed by Rogers and Schmitt (2004)	Survey questions relating to operational, strategic and relative performance
Indicator	VOL	Represents the percentage of the firm's business process that are using the ERP system	Survey questions measuring assimilation of the ERP system
Indicator	DIV	Represents the percentage of the firms functional areas that are using the ERP system	Survey questions measuring assimilation of the ERP system
Indicator	DEP	Represents the level at which the functional areas are using the ERP system	Survey questions measuring assimilation of the ERP system
Control	FirmRev	Measure of the size of the firm	Survey question based on a 7-point scale
Control	Empl	Measure of the size of the firm	Survey question based on a 7-point scale
Control	Time	Time since ERP implementation	Survey question measured in years
Control	ABSCAP	Measure of the firms absorptive capacity	Survey questions measuring firms overall ability to assimilate new technology into the firm
Control	ORGCOM	Measure of the firms organizational compatibility	Survey questions measuring firms overall fit between the ERP and the firms values, beliefs and operating practices

Table 4 (Continued)
Variable Labels and Definitions

Variable Type	Variable in Model	Variable Description	Variable Source
Descriptive	FIRMYRS	Number of years with the firm	Survey question measured in years
Descriptive	AGE	Age of respondent	Survey question measured in years

Table 5
Descriptive Statistics

Variable	N[25]	Mean	Scale Median	Standard Deviation	Min	Max
Study Variables:						
ITEXP1	164	11.92	9.00	2.65	4.00	15.00
ITEXP2	164	11.97	9.00	2.80	5.00	15.00
ITEXP3	164	8.43	6.00	1.56	4.00	10.00
ITKNOW1	164	31.58	27.00	6.99	9.00	45.00
ITKNOW2	164	31.11	27.00	6.64	11.00	44.00
ITKNOW3	164	35.50	30.00	6.86	14.00	50.00
VOL	164	0.78	n/a	0.16	0.10	1.00
DIV	164	0.78	n/a	0.27	0.00	1.00
DEP	164	0.65	n/a	0.26	0.00	1.00
PERF1	164	50.18	45.00	10.54	7.00	76.00
PERF2	164	51.58	40.00	10.33	4.00	73.00
PERF3	164	42.22	36.00	9.05	7.00	62.58
Control Variables:						
FirmRev	164	2.32	n/a	1.08	-0.06	6.00
Empl	164	2.69	n/a	1.72	1.00	7.00
Time	164	6.12	n/a	3.45	1.00	16.00
ABSCAP	164	14.10	12.00	2.24	4.93	20.00
ORGCOM	164	10.51	9.00	2.64	3.00	16.30
Demographics:						
AGE	135	47.56	n/a	9.42	23.00	69.00
FIRMYRS	144	12.72	n/a	9.35	0.00	42.00

Note: Variable definitions are provided in Table 4.
n/a = not applicable

[25] Variables with missing data are replaced with values calculated using the EM Method in SPSS. This method uses a maximum likelihood estimation process and requires that the missing values be completely at random (MCAR). Roderick J.A. Little's chi-square test was used to test whether missing values are MCAR. MCAR requires a non-significant statistical result. The result of Little's MCAR test suggests that the missing values are completely random.

Table 6
Reliability and Correlations of Variable Means

	PERF	ASSIM	ITKNOW	ITEXP	ABSCAP	ORGCOM	Time	FirmRev	Empl
PERF	**.957**	.435**	.265**	.308**	.242**	-.225**	-.110	.171*	.031
ASSIM	.488**	**.848**	.106	.268**	.216**	-.145	-.134	.114	.068
ITKNOW	.218**	.211**	**.967**	.588**	.111	-.212**	-.159*	.250**	.256**
ITEXP	.289**	.270**	.602**	**.894**	.055	-.063	-.104	.137	.103
ABSCAP	.250**	.254**	.127	.058	**.753**	-.479**	-.094	-.001	-.031
ORGCOM	-.184*	-.206**	-.145	-.012	**-.**519**	**.920**	.103	-.003	.050
Time	-.070	-.089	-.143	-.076	-.089	.095	**1.000**	-.028	-.001
FirmRev	.196*	.154*	.251**	.170*	.074	-.059	-.025	**1.000**	.520**
Empl	.020	.134	.212**	.094	-.013	.045	.021	.551**	**1.000**

Note: Amounts on the diagonal represent Cronbach's alpha reliability coefficients (in **bold**). Amounts on upper side of the diagonal represent Spearman coefficients; amounts on the lower side represent Pearson coefficients.

**Significant at the 0.01 level
*Significant at the 0.05 level

Table 7
Results of Confirmatory Factor Analysis – Measurement Model

	Acceptable Fit Standard	Measurement Model
Statistical Test		
Chi-Square		151.41
df		94
Chi-Square/df	<2.0	1.61
Fit Indices		
RMSEA	<0.08	0.061
SRMR	<0.10	0.052
CFI	>0.95	0.970
NNFI	>0.90	0.970
AGFI	>0.95	0.850

RMSEA = Root Mean Square Error of Approximation. Lower values indicate better fit
SRMR = Standardized Root Mean Square Residual. Lower values indicate better fit.
CFI = Comparative Fit Index. Higher values indicate better fit.
NNFI = Non-Normed Fit Index. Higher values indicate better fit.
AGFI = Adjusted Goodness of Fit Index. Higher values indicate better fit.

Table 8
Summary of Overall Fit Statistics – Structural Model*

Model	χ^2	df	χ^2/df	RMSEA	SRMR	CFI	NNFI	AGFI
Structural w/o Controls	98.03	50	1.96	0.077	0.071	0.98	0.97	0.86
Structural w/ Controls	157.50	97	1.62	0.062	0.076	0.97	0.96	0.85

*See Figure 2 and 3 for detailed information on path coefficients.

Table 9
Supplemental Analysis
COSES Customization and Performance

Model	χ^2	df	χ^2/df	RMSEA	SRMR	CFI	NNFI	AGFI
	15.09	12	1.25	0.04	0.03	0.99	0.99	0.94

Table 10
COSES Customization and Competitive Advantage

Model (R2 = .000)		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	3.651	.131	27.786	.000
	MOD	-.040	.504	-.079	.937

a. Dependent Variable: OrgImp4
OrgImp4 = competitive advantage measure
MOD = COSES modification measure

Figure 1
Hypothesized Model

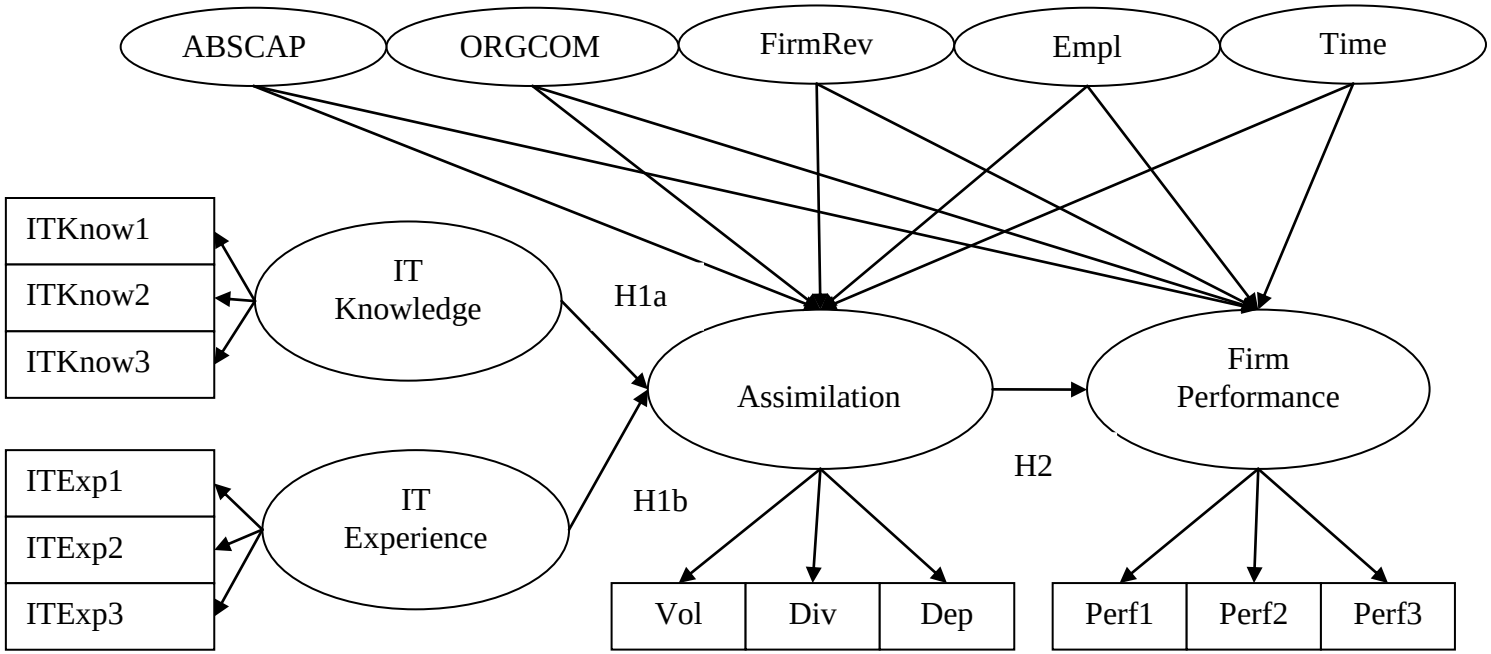
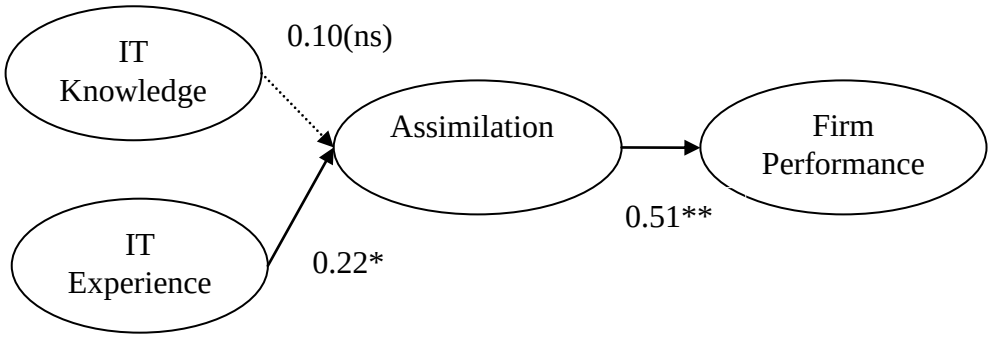
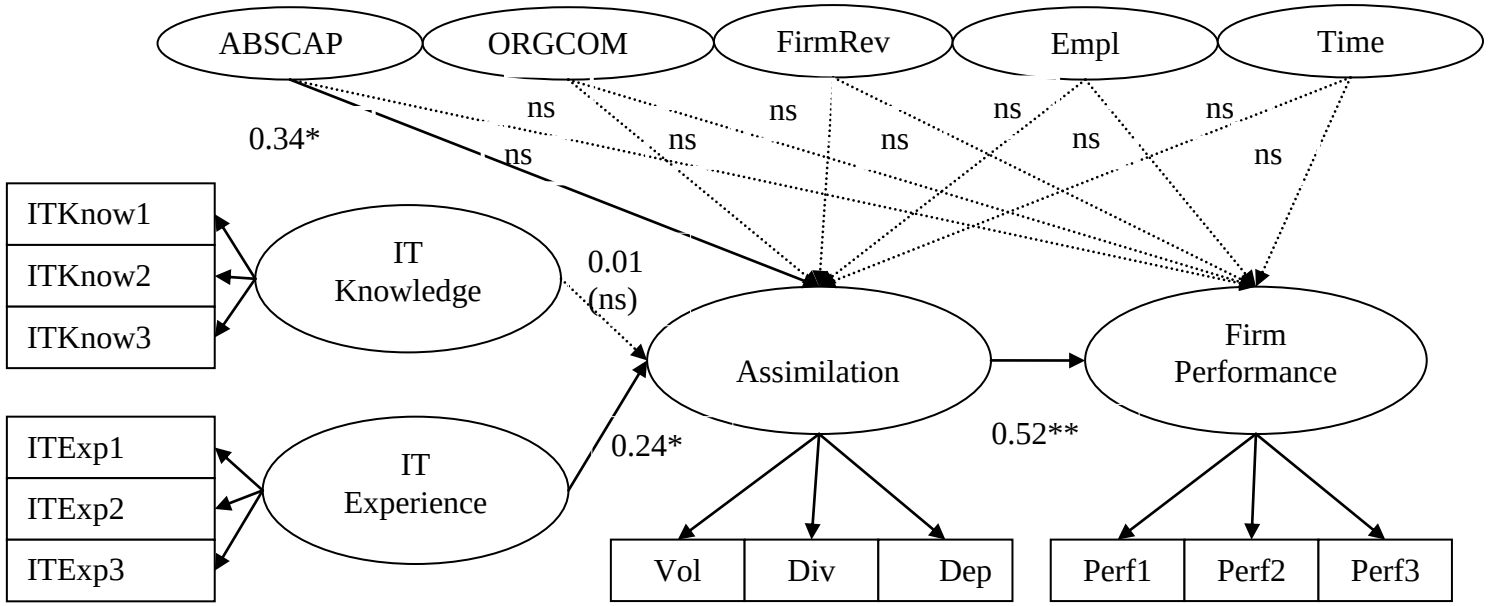


Figure 2
Structural Model without Controls



Chi-Square = 98.03, df = 50, RMSEA = 0.077, CFI = 0.98, NNFI = 0.97, AGFI = 0.86
**Significant at the 0.01 level
*Significant at the 0.05 level

Figure 3
Structural Model with Controls



Chi-Square = 157.50, df = 97, RMSEA = 0.062, CFI = 0.98, NNFI = 0.96, AGFI = 0.85
** Significant at the 0.01 level
* Significant at the 0.05 level
ns = non-significant path

APPENDIX A

ERP Assimilation Survey

1. Introduction

As a customer of VAI, Inc., you are invited to participate in this study designed to assess the success of the assimilation of the open-source ERP software (i.e., software where the vendor provides customer with the source code) your firm purchased. Your candid responses will contribute to a greater understanding of the impact of such software on the performance of your business.

In addition to providing insights into factors influencing firm outcomes, this study is being conducted to fulfill the requirements for a doctoral dissertation at Virginia Commonwealth University. The researcher, Sandra Cereola, can be reached at 540-574-2551 or cereolasj@vcu.edu. Her doctoral committee chairman, Dr. Benson Wier, can be reached at 804-828-7162 or bwier@vcu.edu.

2. Research Study Information

To members of the top management team:

This email is being sent with the approval of VAI, Inc., to solicit responses from the top management team at your firm. If it was sent to you in error, please forward it to the chief executive officer, chief financial officer, chief operations officer, and chief information officer or those who fulfill these functions at your firm.

You can complete this survey at any time; however, we would appreciate a response by FRIDAY, JUNE 20, 2008. Completion of the survey should take approximately 20 minutes. If you find it necessary to leave the survey at any time, you can return at a later time at the point where you left off, as long as you use the same computer.

Results from this empirical study will contribute to a greater understanding of ERP impacts on firm performance. Participation in the survey is strictly voluntary, and you may discontinue your participation at any time. You have the right to choose not to answer any questions that may make you feel uncomfortable. Refusal to participate or withdrawal from participation will not involve any penalty or loss of benefits to which you are otherwise entitled.

YOUR RESPONSES WILL REMAIN ANONYMOUS. Your name will not appear anywhere on this questionnaire. There are no “right” answers; you are only expected to give your opinion. The last part of the survey requests basic demographic information that will be helpful in interpreting the results. When you finish answering the questions, please click the “done” button.

If you have any questions about your rights as a participant in this study, you may contact:

Office of Research Subjects Protection
Virginia Commonwealth University
800 East Leigh Street, Suite 114
P.O. Box 980568
Richmond, VA 23298
Telephone: 804-828-0868

Thank you for your participation.

3. ERP Characteristics

The following questions address modules of the ERP system which you might have adopted.

Indicate the status of the following modules within your organization.

ERP Assimilation Survey

1. Indicate the status of the following modules within your organization.

0 = This module is not relevant for our organization

1 = This module is not in use, but could in principle be put to use in our organization

2 = This module will be used eventually, but the implementation has not started

3 = We are currently implementing this module

4 = This module has been in use for less than 3 years

5 = This module has been in use for more than 3 years

	0	1	2	3	4	5
Financial Management	◯	◯	◯	◯	◯	◯
Distribution Management	◯	◯	◯	◯	◯	◯
Manufacturing Management	◯	◯	◯	◯	◯	◯
Retail Management	◯	◯	◯	◯	◯	◯
EDI Integration	◯	◯	◯	◯	◯	◯
Warehouse Management	◯	◯	◯	◯	◯	◯
Customer Relations Management	◯	◯	◯	◯	◯	◯
E-Business/Portal Technology	◯	◯	◯	◯	◯	◯

2. When was the ERP system implemented (month/year)?

3. If you are a public company, when was the implementation announced to the public (month/year)?

4. Knowledge of Technologies

4. Please indicate your level of knowledge of the following technologies.

	Very low	Low	Neither low nor high	High	Very high
What is your general knowledge of personal computer?	◯	◯	◯	◯	◯
What is your general knowledge of client-server?	◯	◯	◯	◯	◯
What is your general knowledge of LAN?	◯	◯	◯	◯	◯
What is your general knowledge of imagery technology?	◯	◯	◯	◯	◯
What is your general knowledge of multimedia?	◯	◯	◯	◯	◯
What is your general knowledge of CASE?	◯	◯	◯	◯	◯
What is your general knowlede of graphical user interface (GUI)?	◯	◯	◯	◯	◯
What is your general knowledge of objected oriented database?	◯	◯	◯	◯	◯
What is your general knowledge of relational database management systems?	◯	◯	◯	◯	◯

5. Knowledge of application

ERP Assimilation Survey

5. Please indicate your level of knowledge of the following applications.

	Very low	Low	Neither low nor high	High	Very high
What is your general knowledge of internet?	◯	◯	◯	◯	◯
What is your general knowledge of electronic data interchange (EDI)?	◯	◯	◯	◯	◯
What is your general knowledge of e-commerce?	◯	◯	◯	◯	◯
What is your general knowledge of Groupware?	◯	◯	◯	◯	◯
What is your general knowledge of Enterprise Resource Planning (ERP)?	◯	◯	◯	◯	◯
What is your general knowledge of Open-Source Software?	◯	◯	◯	◯	◯

6. Knowledge of systems development

6. Please indicate your level of knowledge of the following systems development.

	Very low	Low	Neither low nor high	High	Very high
What is your general knowledge of traditional system development life cycle (SDLC)?	◯	◯	◯	◯	◯
What is your general knowledge of end-user computing?	◯	◯	◯	◯	◯
What is your general knowledge of prototyping?	◯	◯	◯	◯	◯
What is your general knowledge of outsourcing?	◯	◯	◯	◯	◯
What is your general knowledge of project management practices?	◯	◯	◯	◯	◯

7. Knowledge of management of IT

7. Please indicate your level of knowledge of management of IT.

	Very low	Low	Neither low nor high	High	Very high
Indicate your level of knowledge about the current IS applications (including software, data) assets in your business unit?	◯	◯	◯	◯	◯
How informed are you about the IT budget in your business unit?	◯	◯	◯	◯	◯
How informed are you about the IT strategies in your busines unit?	◯	◯	◯	◯	◯
How informed are you about the IT policies in your business unit?	◯	◯	◯	◯	◯
How informed are you about the IT vision statements in your business unit?	◯	◯	◯	◯	◯

8. Knowledge of access to information

ERP Assimilation Survey

8. Please indicate your knowledge of access to information

	Very low	Low	Neither low nor high	High	Very high
How knowledgeable are you about IT or business people to contact within your organization as a source of information about IT?	◯	◯	◯	◯	◯
How knowledgeable are you about IT or business people to contact outside your organization as sources of information about IT?	◯	◯	◯	◯	◯
How knowledgeable are you about secondary sources of knowledge as source of information about IT?	◯	◯	◯	◯	◯

9. Experience in IT projects

9. Please indicate your level of participation in IT projects

	Never	Almost never	Neither never nor always	Almost always	Always
How often have you participated in and/or led in initiating new IS projects?	◯	◯	◯	◯	◯
How often have you participated in and/or led in identifying the cost and benefits of IS projects before they are developed; preparation of business cases?	◯	◯	◯	◯	◯
How often have you participated in and/or led in managing information systems projects?	◯	◯	◯	◯	◯
How often have you participated in and/or led in developing information systems?	◯	◯	◯	◯	◯

10. Experience in general management of IT

10. Please indicate your level of participation in general management of IT

	Never	Almost never	Neither never nor always	Almost always	Always
How often have you participated in and/or led in creating an IT vision statement regarding how IT contributes to business value and strategy?	◯	◯	◯	◯	◯
How often have you participated in and/or led in developing IT strategy?	◯	◯	◯	◯	◯
How often have you participated in and/or led in creating IT policies?	◯	◯	◯	◯	◯
How often have you participated in and/or led in setting IT budgets?	◯	◯	◯	◯	◯

11. ERP Assimilation

11. Volume:

Please indicate the percentage of the firm's business processes that are using the ERP system:

	Percentage
Business processes	

ERP Assimilation Survey

12. Diversity:

Of the total number of potential functional areas in your firm that might have used ERP, how many eventually used ERP?

Total number of functional areas in your firm	
Number of functional areas using ERP system	

13. Depth:

For each functional area identified above, identify the level at which the ERP system is used:

	Percentage
Operations	
Management	
Decision Making	

Other (please specify area and %)

12. Organizational impact of ERP System

14. Please indicate your level of agreement of the operational impact of the ERP system

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Our ERP reduces organizational costs	◯	◯	◯	◯	◯
Our ERP improves overall productivity	◯	◯	◯	◯	◯
Our ERP enables e-business/e-commerce	◯	◯	◯	◯	◯
Our ERP provides us with competitive advantage	◯	◯	◯	◯	◯
Our EPR increases customer service/satisfaction	◯	◯	◯	◯	◯
Our ERP facilitates business process change	◯	◯	◯	◯	◯
Our ERP supports decision making	◯	◯	◯	◯	◯
Our ERP allows for better use of organizational data resource	◯	◯	◯	◯	◯

15. What impact has implementing your ERP system had on your firms performance?

Please choose from the following drop down menu.

	Percentage
Performance	

ERP Assimilation Survey

16. What impact on the following areas has implementation of ERP had on your firm?

	Significant decrease	Slight decrease	Neither decrease nor increase	Slight increase	Significant increase
Productivity	◯	◯	◯	◯	◯
Profitability	◯	◯	◯	◯	◯
Market Share	◯	◯	◯	◯	◯

17. What impact on the following areas has implementation of ERP had on your firm relative to competitors in your industry?

	Lower than competitor	On Par with competitor	Higher than competitor	Don't know
Productivity	◯	◯	◯	◯
Profitability	◯	◯	◯	◯
Market Share	◯	◯	◯	◯

18. Assume that a score of "10" would be assigned to a firm in your industry that you personally view as being the most successful in applying their ERP system for that specific activity.

Compared to other firms in your industry, how do you evaluate your firm's performance in effectively applying your ERP system for each of the following activities?

	n/a	0	1	2	3	4	5	6	7	8	9	10
Financial Management	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Distribution Management	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Manufacturing Management	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Retail Management	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
EDI Integration	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Warehouse Management	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Customer Relations Management	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
E-Business/Portal Technology	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

19. Assume that a score of "10" would be assigned to a firm in your inudstry that you personally view as being the most successful in applying their ERP system for that specific activity.

Compared to other firms in your industry, how do you evaluate your firm's peformance in applying your ERP system in support of each of the following business strategies?

	n/a	0	1	2	3	4	5	6	7	8	9	10
a. being a low cost producer	○	○	○	○	○	○	○	○	○	○	○	○
b. having manufacturing/operations flexibility	○	○	○	○	○	○	○	○	○	○	○	○
c. enhancing supplier linkages	○	○	○	○	○	○	○	○	○	○	○	○
d. enhancing customer linkages	○	○	○	○	○	○	○	○	○	○	○	○
e. providing value-added services	○	○	○	○	○	○	○	○	○	○	○	○
f. enhancing existing products/services	○	○	○	○	○	○	○	○	○	○	○	○
g. creating new products/services	○	○	○	○	○	○	○	○	○	○	○	○
h. entering new markets	○	○	○	○	○	○	○	○	○	○	○	○

20. For each module adopted, please indicate the percentage that has been modified.

	Percentage
Financial Management	
Distribution Management	
Manufacturing Management	
Retail Management	
EDI Integration	
Warehouse Management	
Customer Relations Management	
E-Business/Portal Technology	

13. Other Organizational Questions

ERP Assimilation Survey

21. Absorptive Capacity:

For the following questions, please indicate whether you agree or disagree.

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
Prior to ERP implementation, our employees in general had extensive experience in using computer based applications in their work processes.	◯	◯	◯	◯	◯
It is well known who can help solve problems associated with the ERP package.	◯	◯	◯	◯	◯
Our company can provide adequate technical support to using ERP.	◯	◯	◯	◯	◯
Our company provides ERP training opportunities to employees on a regular basis.	◯	◯	◯	◯	◯

22. Organizational Compatibility:

For the following questions, please indicate whether you agree or disagree.

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
Using ERP in our company created a disruption in the workplace at first.	◯	◯	◯	◯	◯
Using ERP in our company decreased productivity at first due to time to learn.	◯	◯	◯	◯	◯
Using ERP in our company required an overall change in the values, norms and culture within our company.	◯	◯	◯	◯	◯

23. Capital Investment Analysis & Return Analysis:

For the following questions, please indicate whether you agree or disagree.

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
The top management team performed a formal capital investment analysis prior to purchasing the ERP system.	◯	◯	◯	◯	◯
Since the ERP system was implemented, performance benchmarks relating to the system are assessed on a regular basis.	◯	◯	◯	◯	◯

If applicable, please indicate the analysis used to assess the ERP system (e.g., ROI, EVA, IRR, NPV) and indicate how often assessments are performed.

14. Demographic Information

Nearing the end! Tell us more about yourself and your firm.

ERP Assimilation Survey

24. Respondent's Position:

- ◯ Chief Executive Officer
- ◯ Chief Operating Officer
- ◯ Chief Financial Officer
- ◯ Chief Information Officer
- ◯ Other member of the Top Management Team
- ◯ Other (please specify)

25. Please select from the following drop down list:

	Revenue ($ mil.)
Firm's Annual Revenue	

26. Please choose from the following drop down list:

	Number of employees
Enterprise Employment:	

27. Gender:

- ◯ Female
- ◯ Male

28. Number of years with the firm:

29. Age:

15. Thank you!

Thank you for your time and consideration. Your input is extremely valuable to this study and is greatly appreciated. Please contact me at 540-574-2551 or cereolasj@vcu.edu if you would like to obtain the results of this study or with any questions or concerns.

Sincerely,
Sandra Cereola
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School of Business
Virginia Commonwealth University