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ERP and E-Business Integration in the Extended Enterprise

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ABSTRACT

Building on Resource Based View theory, we investigate the complementary effect between ERP and e-business technologies, and the impact of such effect on business performance. Different from previous studies that assume ERP and e-business technologies have direct effects on firm performance, this study argues that it is the complementarily use of the two IT resources to build integration capabilities that is more likely to create business value. We use a sample of 150 U.S. manufacturing firms and two different approaches to measure the complimentary effect. We present new empirical evidence that the complementary effect between ERP and e-business technologies in creating business value is stronger than the main effects of ERP or e-business technologies alone. Accordingly, firms should utilize and deploy ERP and e-business technologies in a mutually reinforcing manner by building both system integration and business process integration capability.

Keywords
Complementarity, ERP, e-business, resource-based view

INTRODUCTION

The Enterprise resources planning (ERP) systems are large commercial software packages that standardize business processes and integrate business data throughout an organization (Markus and Tanis, 2000c). These systems codify and organize an enterprise’s business data into an integrated database, and transform the data into useful information that supports business decisions (Norris, 2000). Although the benefits of ERP are considerable, traditional ERP systems that streamline and integrate internal processes improve efficiency only within the boundaries of an enterprise. Because firms’ value chains increasingly extend beyond their boundaries and include other firms within their business ecology, it is important to improve operational performance along the whole supply chain. Although Electronic Data Interchange (EDI) helps a few large firms exchange data with their business partners, most medium and small companies are not able to afford EDI technologies due to its high installation costs as well as its implementation complexity. Most firms find it difficult to move important information across the supply chain in a timely manner. Thus, the full potential of ERP systems can not be extended to the entire supply chain due to lack of common communication networks (Swaminathan and Tayur, 2003).

E-business technologies have exploded on the scene in the past couple of years, and some advocates claim that they are the ultimate solution to this information exchange problem in the extended enterprise. In this paper, E-business technologies are defined as the Internet-based technologies, such as Intranet, Extranets, Websites, and EDI communication technologies for performing e-business functions (Geoffrion and Krishnan, 2001). By breaking down institutional barriers and rendering cross-organizational boundaries almost obsolete, e-business technologies allow that the information made available from the ERP systems be shared with other firms in the extended supply chain (Swaminathan and Tayur, 2003). E-business technologies serve to extend the original value proposition of ERP (Gonzalez, 1998; Larsen, 2000), offer an ERP-based organization the opportunity to build interactive relationships with its business partners (Ash and Burn, 2003a, b), and bring together previously separate groups information instantaneously at a very low cost (Norris, 2000). Together, E-Business technologies comprise the electronic portion of the electronically integrated enterprise, and ERP comprises the internal enterprise information portion (Norris, 2000). Figure 1 shows how ERP fits with e-Business.
As more and more established organizations realize that they need to form alliances with their customers, partners and suppliers over electronic networks, integrating e-business technologies with ERP systems becomes a critical issue (Markus et al. 2000a, b). Some IS researchers have identified ERP and e-business integration, as one of the most important IS areas for future research (Swaminathan and Tayur, 2003; Bendoly et al. 2004). Others indicate that reconfiguring and integrating ERP systems with front-end web-based systems to support e-business initiatives should be at the top of the list for IS executives (Sambamurthy et al., 2000). Research in this area has just begun and more needs to be undertaken (Straub and Watson, 2001).

LITERATURE REVIEW

Business Value of ERP

Using case studies and a survey, Mabert et al. (2000, 2003) report that the most improvements after using ERP are in intangible areas such as increased interaction, quicker response time, integration of business process, and availability and quality of information. The least improvements are in traditional cost measures such as direct operating costs, inventory levels and cash management. At firm level, Hitt et al. (2002) compared financial data of 350 ERP adopters and non adopters and found that ERP adopters show positive but not consistent performance results on productivity, profitability, and market value measures. They found that while ERP adopters show a better performance on productivity, ROA, inventory turnover, and profit margin, they have a significant negative performance on ROE. They also found some evidence of a decline in productivity and business performance shortly after completion of the implementation. Partially replicating Hitt et al.’s work, Aral et al. (2005) collect financial data of 623 US firms that are ERP adopters over a 7-year-period (1998~2005) to investigate business value of ERP. Their results show that using ERP systems improve productivity, inventory turnover, and asset utilization, but have no association with ROA, ROE, and Profit margin. Poston and Grabki (2000) compared 54 ERP adopters and non adopters and found that ERP implementation is associated with an unexpectedly significant cost increase (COGS and SG&A) one year after implementation, a significant decrease in employee number, and no association is found with income changes. Gattiker and Goodhue (2005) use plant level data to show that ERP can deliver plant level benefits to firms including better information, more efficient internal business process, and better coordination.

While the existing studies have significantly expanded our understanding of ERP systems’ business value, the results are mixed with some indicating improved value and others not. A recent review of IT business value research (Melville et al. 2004) suggests that it is no longer adequate to look only at the IT within the firm, but to also look at interfirm IT linkages because some performance improvements such as inventory turnover, better asset utilization, or profitability depend on improved processes and information flows “between” firms. Jacobs and Bendoly (2003) also pointed out that most existing ERP research focuses on the impact of an ERP system itself, but not on the much richer area of ERP extendibility. With the growing popularity of B2B and B2C e-commerce systems, there should be a strong interest in assessing how to best integrate the functionality of these systems with ERP systems to provide competitive advantage for the firm.
**Business Value of e-Business technologies**

Using self-reported survey data, Barua et al. (2004) and Zhu et al. (2004a, 2005) found a positive and significant relationship between e-business use and firm performance. However, they stressed the limitation in their studies is that the subjective performance measures could potentially induce biases, and therefore, firm level accounting data is needed to confirm these findings. Yet, using objective accounting data, Zhu et al.’s (2002, 2004b) studies show that e-business use is significantly associated with COGS and Inventory turnover, but it has weak or no association with ROA and Gross Margin.

IS researchers indicate the limitation of current e-business studies is neglecting the important role of ERP in e-business settings, and encourage future studies on e-business to focus on more specific questions about how a firm integrates the Internet with its existing internal IS such as ERP systems (Zhu et al. 2004a). Jacobs and Bendoly (2003) pointed out that while buzzwords like “B2B”, “B2C”, and just about anything else preceded by an “e-” seem to have taken center stage, yet ironically, each of these new terms at their most basic levels represent extensions of ERP systems to the customers and to the suppliers. A true e-business enabled firm needs the support from a well-tuned ERP system, since ERP is the core to fulfill the promises made on the web pages. Without clean internal processes and data that are provided by ERP systems, e-business may be just flashy web pages with no real substance behind (Norris, 2000).

Overall, the foregoing studies of ERP and e-business technologies indicate that they each contribute to the business value of IT. However, none of the previous studies examined the role of ERP systems linked with e-business technologies in interfirm or interorganizational systems. Melville et al. (2004) suggest that such interorganizational linkages might produce greater benefits than either technology alone. Consequently we propose to investigate both the independent and the complementary effect of ERP systems and e-business technologies on business performance. In order to have a solid theoretical framework to guide the research, we draw from the resource-based theory to develop theoretical propositions.

**Theoretical Background: Resource Complementarity in RBV**

The Resource-Based View (RBV) argues that firm resources are heterogeneously distributed across firms. When the firm resources are valuable, rare, imperfectly imitable, and nonsubstitutable, they could create competitive advantages, which in turn could explain the differences in firm performance (Barney, 1991; Wernerfelt, 1984). Moreover, resources tend to survive imitation because of isolating mechanisms such as causal ambiguity, social complexity, and history dependence (Barney, 1991). The RBV (or its variations) has been applied by information systems (IS) researchers to analyze the business value of IT (Wade and Hulland, 2004). Resources and Capabilities are two terms that have been frequently used in the RBV theory. This paper distinguishes between “resources” and “capabilities” based on the definitions in RBV literature (Makadok, 2001).

Resources are inputs into a firm’s production process, such as capital, equipment, information systems, and individual employees. Capabilities, in contrast, refer to a firm’s capacity to deploy resources using organizational processes. Capabilities can be viewed as the capacity of a bundle of resources to perform some task or activity. Through continued use, capabilities become more difficult for competitors to understand and imitate (Ravichandran and Lertwongsatien, 2005).

Most previous studies based on the RBV theory posit a direct relationship between IT resources and firm performance (Mata et al., 1995). More recently, some researchers have emphasized that the IT resource is likely to affect firm performance only when it is deployed to create unique “complementarities” with other IT or other firm resources (Powell and Dent-Micaleff, 1997). Complementarity represents an enhancement of resource value and arises when a resource produces greater returns in the presence of another resource than by itself (Milgrom et al. 1991). Resources rarely act alone in creating or sustaining competitive advantage, and this is particularly true of IS resources that, in almost all cases, act in conjunction with other firm resources to provide strategic benefits (Wade and Hulland, 2004). While RBV theory argues that the issue of complementarity is an important one, yet, the nature of this role is not well understood (Ravichandran and Lertwongsatien, 2005). RBV and IS Researchers concede IT-based success rests on the ability to “fit the pieces together” but as yet we have little understanding about how this might happen (Wade and Hulland, 2004).

Why is the complementarity between IT resources more possible to provide firms competitive advantage than one resource alone? Based on the RBV literature, we propose two explanations for the role of complementarity in IS context. (1). In general, physical technology such as a complex information system, by itself is typically imitable. If one firm can purchase these physical tools of production, then other firms should also be able to purchase these physical tools, and thus such tools should not be a source of sustained competitive advantage (Barney, 1991). On the other hand, if a firm can exploit physical technology involving the use of socially complex firm resources, the synergies among them is far more difficult to be imitated (Barua et al. 2004; Zhu, 2004b). Several firms may all possess the same physical technology, but only some of these
firms may possess the social relations, culture, traditions, etc. to fully exploit this technology in implementing strategies (Barney, 1991).

(2) Complementarity means not only the co-presence of the two resources as indicated above, but that the two resources are used in a mutually reinforcing manner. How effective a firm is in using two ITs in a reinforcing manner to support and enhance its business core competencies is difficult. Therefore, complementarily leveraging resources is considered as a firm-specific capability (Makadok, 2001). Numerous studies have commented that integrating IT resources (systems) to build a flexible and sophisticated IT infrastructure requires both considerable time and expertise (Markus, 2000c). Although the individual components that go into the infrastructure are commodity-like, the process of integrating the components to develop an infrastructure tailored to a firm’s strategic context is complex and imperfectly understood (Bharadwaj, 2000).

Complementarily integrating ERP and e-business technologies could be particularly difficult since it involves not only the focal firm itself, but several partners in the supply chain (Sambamurthy et al. 2000). As firms develop IT infrastructures that span entire organizations, linking key suppliers and customers, they evolve elaborate rules regarding the distribution and management of hardware, software, and reengineer the whole business processes among the supply chain (Bharadwaj, 2000; Ross et al. 1996). The new business processes that supported by a well integrated ERP and e-business system is like dominoes in a row; each new transaction sets off a cascade of new events. However, due to such difficulty, the possibility of imitation decreases. Bendloy et al. (2004) argue that once the entire value chains are acting as formidable entities, competing against each other for similar markets, using inter-firms ITs such as ERP and e-business technologies to cooperate, the structures of these partnered communities are both increasingly idiosyncratic and hard to duplicate, which strengthens the sustainability of the competitive advantages of their constituents.

MODEL AND HYPOTHESES

Since the RBV theory provides two different rationales to explain complementarity, we propose two corresponding research models to investigate ERP, e-business technologies, and their complementary effect on firm performance. Model 1 represents the first rationale that RBV theory provides: Firm resources are considered complementary when the presence of one resource enhances the value of effect of another resource. This interaction perspective of complementarity is typically operationalized using multiplicative terms in statistical analysis (Ravichandran and Lertwongsatien, 2005). Hence, we measure the level of complementarity by the product of ERP and e-business technologies variables (Figure 2).

The second perspective that RBV theory conceptualizes resource complementarity is based on how resources are utilized and deployed; complementaries arise when resources are used in a mutually reinforcing manner (Ravichandran and Lertwongsatien, 2005). RBV argues the complementarily deploying and utilizing resources as a firm-specific capability. Model 2 assesses the complementarity capability by measuring how ERP and e-business technologies are integrated and
utilized at two levels (Figure 3). The first level measures how the two technologies are integrated at system level. The second measures how the integrated ERP and e-business system is utilized at business process level.

The reason we gauge the complementarity at two levels is based on Markus’s architecture of business/system integration (Markus, 2000d). System integration refers to the creation of tighter linkages between different computer-based information systems and databases. System integration is often required to achieve business integration; however, even when system integration is achieved, the goals of business integration may not be. Due to the concern of information leakage, firms usually are reluctant to exchange business information with their business partners (Cohen and Fisher, 2000). Two firms may both achieve high level of system integration, but their business coordination level varies. System integration is viewed as a prerequisite and facilitator of business integration, but does not guarantee a firm’s willingness to achieve higher level of business integration (Markus, 2000d). Therefore, we need to measure both system integration and business process integration.

**Hypothesis Development:**

Based on the theoretical foundation discussed above, ERP systems focus on internal process efficiency and effectiveness, and can coordinate information across different departments within a company. ERP systems are expected to affect internal firm operations by decreasing internal coordination costs (Poston and Grabski, 2000). On the other hand, e-business technologies are focused on external, cross-enterprise process efficiency and effectiveness. They can reduce external coordination costs and reap the benefits of supply chain integration (Psoton and Grabski, 2000). Therefore, we propose the following hypotheses:

**H1 and H2:** A firm with more complete IT resources (ERP Modules and e-business technologies) is more likely to exploit the value of IT, and has better firm performance.

Integrating ERP and e-business is extremely complex. It often comes in numerous configuration tables that must be customized to suit a firm’s business needs. It also requires substantive changes in business processes, routines, and roles. Business processes such as procurement and fulfillment are inherently complex, and enabling these transactions over electronic networks is more challenging (Sodhi, 2001). Such complexity places substantial strain on a firm’s knowledge resources and absorptive capacity (Ross, 2003). Therefore, successfully integrating ERP systems and e-business technologies is considered to be valuable, heterogeneously distributed, difficult to be imitated, and hard to be substituted, which meets the four criteria that RBV theory proposes as a source of competitive advantages. Accordingly, we hypothesize that

**H3:** The complementary effect between ERP and e-business technologies is stronger than the main effects of ERP or e-business technologies alone.
METHODOLOGY

Data:
To test our research model, a questionnaire was designed to collect data on each of the variables in the model. The sampling is selected randomly within U.S. manufacturing industry. Interviews were conducted only with those companies that make use of ERP in conducting their business. Eligible respondents to the survey were the individuals who are considered the most knowledgeable about ERP and e-business use in their companies, such as a CIO or IS manager. Our target completes were 150 interviews.

Instrument Validation:
Constructs and measurement items used in this research are adapted from previously validated measures, or are developed on the basis of literature review. The process of operationalization of constructs as well as prior research support, are listed in the Appendix A. To validate the instruments, we conducted a confirmatory factor analysis using partial least squares (PLS). For reflective constructs, we examined convergent validity, construct reliability, and discriminant validity. The constructs meet all the requirements.

RESULTS AND DISCUSSION

Empirical results of Model 1
Model 1 uses the most common approach of testing a complementary effect – the product terms approach. Figure 4 shows that both ERP modules and e-business technologies have positive and significant affects on firm performance (0.219*** and 0.180** respectively). The results indicate that the more comprehensive ERP modules and e-business technologies a firm implements, the higher firm performance it may receive. Hypotheses H1 and H2 are supported.

The interaction effect between ERP and e-business technologies is strong and significant (0.196***). The result shows that the presence of one resource enhances the value of effect of another resource. One unit investment in e-business technologies could increase ERP’s contribution to firm performance by 0.196 units. The model can explain 19.8% of the variance in firm performance.

Lastly, firms are eager to know when their investments on ERP systems can be paid back. Using year dummy variables, we found that firms start to feel some significant performance improvement one year after their ERP implementation (0.148*), before that, the performance improvement is marginal (0.018). The most significant performance improvement happens after five years of using ERP systems (0.287***).

Figure 4. Empirical Results (Model 1: Product Term Approach)
Empirical results of Model 2

Figure 5 shows the results of model 2. ERP modules and e-business technologies again show positive and significant impacts on firm performance. More interestingly, the complementary effect between ERP and e-business technologies is stronger than the main effects of ERP or e-business technologies alone, and the magnitude (0.283) is greater than that in the model 1. The result shows that while the co-presence of two technologies is likely to be a source of competitive advantage, resource complementarity based on how the two resources are utilized and deployed in a firm could contribute more in creating business value to firms. This finding also confirms Devaraj and Kohli’s argument (2003) that the driver of IT impact may not be the investment in the technologies, but the actual usage of the technologies.

By breaking down the complementarity effect, we can see the relative contribution of system integration and business process integration to business performance. While system integration represents a firm’s technical ability to do business cooperation, process integration stands for a firm’s willingness and actual level of doing business cooperation. Although system integration is necessary and difficult to achieve, a firm’s willingness to do a higher level of business process integration might be more important. Our results show that the magnitude of business process integration (0.698*0.283) is greater than that of system integration (0.340*0.283) in creating business value.

Managerial Implication and Discussion

First, since system integration and process integration need huge investments, both in money and in time, they are considered as risky investments. In addition, business process integration is a particularly challenging task since a firm has to convince every department in its organization, business partners, suppliers, and especially customers that each entity along the supply chain will benefit from information sharing. Whether the cost and effort invested in the system and process integration would be justified for the organization is questionable. Based on our results, we show that the investments on integration would pay off. The higher level of system and business integration a firm achieves, the better firm performance it would receive.

Second, referring back to our research question about how firms could build their complementarity between ERP and e-business technologies, we show that at the system integration level, a firm should tightly integrate its internal ERP and front-end e-business systems. More importantly, outside the focal firm, it should allow its ERP system assessable to its business partners either by an extranet connection, or by integrating its ERP system directly with business partners’ information systems, as the two approaches illustrated in Figure 1.

Third, at the business process integration level, firms should utilize the integrated ERP and e-business system to build firm specific business integration capability, such as sharing inventory, production planning and sales forecasting information.
Research shows that close business process integration can reduce the bullwhip effect, decrease inventory level, and accelerate products’ time to market (Cohen and Fisher, 2000). A firm is encouraged to share business information by utilizing what the integrated IT system enables. Barney (1991) indicates that relatively few firms have been able to deeply embed their information processing system into their daily business process and management decision-making process. The inherent difficulty of creating close business-IT alignment may hold the potential of sustained competitive advantage for those than can do so.

CONCLUSION
ERP systems, when integrated with e-business technologies properly, will support a firm’s business to business integration to streamline the flow of materials and information in supply chains. This complementary effect has been proposed by several IS researchers as being the mechanism to fully exploit the value of information technology (Ash and Burn, 2003a, b; Markus, 2000a, b, c, d; Swaminathan and Tayur, 2003), but to our knowledge has not been empirically tested before. The present study provides empirical evidence that ERP and e-business technologies do complement each other. The complementary effect between ERP and e-business technologies is stronger than the main effects of ERP or e-business technologies alone in creating business value.

References


## Appendix A

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Indicators</th>
<th>Literature</th>
</tr>
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<tbody>
<tr>
<td><strong>ERP Module</strong></td>
<td>Purchasing module&lt;br&gt;Inventory/Material Management module&lt;br&gt;Production planning/Manufacturing module&lt;br&gt;Sales/Order enter module&lt;br&gt;Distribution/Logistic module&lt;br&gt;E-retailing module&lt;br&gt;Data warehouse/Business intelligence module&lt;br&gt;Advanced planning and scheduling module&lt;br&gt;Customer relationship management module</td>
<td>Hitt et al., 2002</td>
</tr>
<tr>
<td><strong>E-business technologies</strong></td>
<td>extranet&lt;br&gt;intranet&lt;br&gt;website&lt;br&gt;EDI</td>
<td>Zhu et al., 2002, 2004</td>
</tr>
<tr>
<td><strong>ERP and EB System Integration</strong></td>
<td>To what extent is your firm’s&lt;br&gt;ERP system integrated with your front-end e-business systems?&lt;br&gt;ERP system integrated with your business partners’ information systems?&lt;br&gt;ERP system accessible by your business partners via a web-site, EDI, or other electronic networks?</td>
<td>Wyse and Higgins, 1993</td>
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<tr>
<td><strong>Business Process Integration</strong></td>
<td>Share inventory availability or stock level&lt;br&gt;Share production planning or schedule capacity&lt;br&gt;Share demand and forecasting information</td>
<td>Markus, 2000; Forhlich, 2002</td>
</tr>
<tr>
<td><strong>Cost Efficiency</strong></td>
<td>Operational costs&lt;br&gt;Procurement costs&lt;br&gt;Inventory costs</td>
<td>Hitt et al., 2002 ; Porter, 1998</td>
</tr>
<tr>
<td><strong>Differentiation</strong></td>
<td>Quality of customer service and support&lt;br&gt;On time delivery&lt;br&gt;Product quality</td>
<td></td>
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