The Effect of ERP Systems Competences on Business Process and Organizational Performance

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ABSTRACT

Due to the research designs used and the nature of the variables included in prior research models, the evidence on the contribution of ERP systems to firm performance is not entirely consistent. This study synthesizes the process-oriented and resource-based theoretical perspectives and proposes a research model that investigates the process through which organizations generate business value from their ERP systems investments. In doing so, the study examines the role of ERP systems competences and business process performance in enhancing organizational performance. The results show that the ERP technical and human competences and the complementarity between them have a positive effect on business process performance. The results also show that business process performance is an important factor that mediates the relationship between ERP systems competences and organizational performance. The research findings offer valuable contributions to the theory and practice on how ERP systems enhance organizations performance.

Keywords: ERP systems, organizational performance, business process performance, ERP systems competences.

INTRODUCTION

The contribution of enterprise resources planning (ERP) systems to organizational performance has received great attention in prior accounting information systems (AIS) research, which is matched by the large investments in ERP systems over the last two decades. However, the evidence from early AIS studies regarding the incremental contribution of ERP systems to organizational performance is not entirely consistent (HassabElnaby et al., 2012; Wieder et al., 2006). Very few studies show evidence of ERP systems payoff that is measurable across limited financial ratios (Poston and Grabski, 2001; Hunton et al., 2003). The lack of consistent evidence of the performance impact of ERP systems is attributed to the research models and methodologies used in ERP systems payoff studies (Wieder et al., 2006). For instance, prior studies focus less on the impact of ERP systems at the business process level but pay more attention to the organizational-level performance impact (Matolcsy et al., 2005; Wier et al., 2007). Ignoring the business process performance impact of ERP systems reduces the chance of finding evidence of the impact on organizational performance (Elbashir et al., 2008; Davern & Kauffman, 2000) because unrelated factors may confound the effect of ERP systems (Melville et al., 2004; Davern & Kauffman, 2000).

ERP systems are expected to enhance organizations' performance mainly because of their role in supporting business processes (re)design, thereby enabling timely access to consistent information across diverse functional areas of the organization (Grabski et al., 2011; Weir et al., 2007). As such, achieving the desired performance outcome from ERP investments will require a significant amount of business process re-engineering (BPR) (Cheng & Wang, 2006; Dorien & Wolf, 2000). BPR helps organizations to align their business processes with the ERP systems concept, whereby business process benefits are achieved (O'Leary, 2000; Weir et al., 2007). However, prior ERP systems studies take BPR for granted and assume that it is a natural outcome of any ERP systems implementation. Prior research also indicates that achieving organizational performance of ERP systems requires a great deal of organizational commitments towards investing in complementary ERP-related human and technical resources (Cheng & Wang, 2006; Dorien & Wolf, 2000), which are considered the key factors for the success of ERP systems (Stratman & Roth, 2002; Mata et al., 1995).

The purpose of this study is to revisit the ERP systems payoff theme and propose a research model that explains the process through which ERP systems contribute to organizational performance. In doing so, we draw on the process-oriented and the resource-based views of the firm and propose a research model that explicitly considers the role of business process performance related to BPR as mediating the relationship between ERP systems resources and organizational performance (Mooney et al., 1995; Barua et al., 2000; Tallon et al., 2000; Soh & Markus, 1995; Subramani, 2004). Two ERP systems resources, human and technical competences, are depicted in the research model as the antecedents of organizational performance impact of ERP systems, whereby both their individual and complementary effects on ERP performance impact were tested. Drawing on recent AIS studies, the research model examined in this study depicts the performance impact of ERP systems at the business process and organizational levels (Elbashir et al., 2008; Irani, 2002; Hunton et al., 2003; Nicolaou et al., 2003).

This study makes several contributions to the ERP literature. First, we apply the concept of IT competences to the ERP setting and break down ERP competences into technical and human aspects while examining their roles, separately and jointly, in ERP business value creation. Second, we propose theoretically and examine empirically the framework of the impact of ERP systems technical and human competences on firm performance via business process. Our proposition and examination enriches ERP theory and presents some evidence in relation to the process of ERP systems business value creation. Finally, our empirical results justify the breakdown of ERP resources into technical and human parts by showing different effects (i.e. direct and indirect) of the technical and human competences of ERP systems on organizational performance.

The remainder of the paper is organized as follows: the next section describes the theoretical foundation and research hypotheses. Then, the methodology and results are described. Finally, the findings, limitations, and recommendations for future research are discussed.

THEORY AND HYPOTHESES DEVELOPMENT

Demonstrating the bottom-line contribution of ERP systems has been a major challenge for AIS researchers over the last two decades (Stratman 2007; Wier et al., 2007). Early studies show that ERP systems investments have limited effect on organizational performance (McAfee, 2002; Poston & Grabski, 2001). However, there is now a consensus among researchers that ERP systems can help organizations to improve their operational efficiency and effectiveness (Wier et al., 2007). The challenging research question now is not whether ERP systems create business value, but a richer understanding of the processes through which ERP systems create value to the organization (Melville et al., 2004). Answering these questions requires opening the "black box" of the basic research model of ERP systems that was tested in prior ERP payoff studies, which proposes a direct relation between ERP systems investments and organizational performance. Decoding the "black box" will require examining both the organizational resources that complement ERP systems investments and the processes through which organizations convert ERP systems investments into organizational performance.

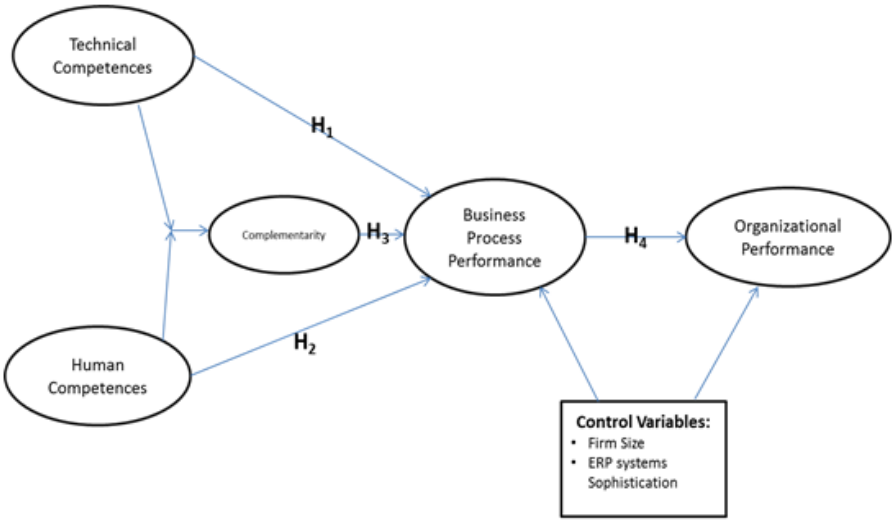
The resource-based view suggests that acquiring ERP systems guarantees neither positive return on investment nor improvement in other indicators of competitive advantages (Stratman, 2007; Beard & Sumner, 2004; Mata et al., 1995). This is because ERP systems are a public commodity that can easily be procured in the market by all organizations. To achieve competitive advantages from their ERP systems investments, organizations will need to invest in other complementary resources including technical and managerial resources (Melville et al., 2004; Barua et al., 2000). These resources are necessary for exploiting ERP systems investments and creating capabilities and competences that are necessary for enhancing competitive advantage (Barney et al., 2001; Teece et al., 1997; Mata et al., 1995). Drawing on the Melville et al. (2004) framework of IT business value, we propose technical and human competences, and the synergy between them as the drivers of business process performance.

Most prior ERP systems payoff studies used organizational performance as the dependent variable of the research models. Recent studies argue that the organizational performance impact of ERP systems can be best measured at its immediate (business

process) where the systems are used (Mooney et al., 1995; Tallon et al., 2000; Subramani, 2004; Melville et al., 2004; Ray et al., 2005; Grabski et al., 2011; Weir et al., 2007). Failing to examine the ERP systems payoff at the business process level may reduce the ability to explain effectively how, why, or why not the business value is created from ERP systems (Elbashir et al., 2008). We examine the business value of ERP systems in this study at both the business process and organizational levels.

Figure 1 depicts the conceptual model tested in this study. We draw on the process-oriented approach and the resource-based view perspective to motivate and test a set of factors as the enablers of the performance impact of ERP system. The performance impact of ERP systems is examined at both the business process and organizational levels. Two ERP systems competences constructs, *human* and *technical*, are modeled to have association individually and jointly with the business process performance of ERP systems. The research model also suggests that the business process performance mediates the relation between the ERP competence constructs and organizational performance.

Figure 1: The Conceptual Model



ERP Systems Competence and Business Process Performance

The value of ERP systems stems from their ability to integrate diverse business processes and functional areas as well as enabling management's need for timely access to consistent information that are required for managerial decisions (Grabski et al., 2011). Important performance outcomes of ERP systems are informational, automational, and transformational benefits (Ramirez et al., 2010). The *informational* benefits are enabled

by the ERP systems as a result of managing all transactional data that are generated by business processes and functional areas to create a database across the whole organization. The *automational* benefits include operational efficiency of the business processes, such as saving in time and labor costs that arise as the result of using the ERP systems to automate business processes. The *transformational* benefits arise as the result of using the ERP systems to (re)design business processes and innovative activities that contribute to the enhancement of the operational effectiveness (Subramani, 2004).

Achieving business process benefits from ERP systems investments is not a straightforward process and will require the firm to build specialized ERP resources including technical and human competences that will enable the organization to leverage the installed ERP systems (Stratman & Ruth, 2002). We include these two competences, ERP technical and human, in our research model as the antecedents of the ERP performance (Melville et al., 2004).

ERP Technical competences is a multifaceted construct that captures the technical knowledge and expertise that organizations need prior to and post ERP systems implementation. These include competences that enable strategic planning for the system, provision of the necessary physical and human resources, and resolving ERP technical challenges (Meliville et al., 2004; Stratmen & Roth, 2002). Technical competences enable organizations to implement BPR techniques and align the newly (re)designed business processes with an effective implementation of the ERP system. ERP technical competences also allow organizations to engage in continuous improvement of their ERP systems implementation to continuously improve the alignment of systems and business processes. Such an alignment will help the organization to achieve operational efficiency and effectiveness of their business processes. This leads to the following hypothesis:

H_1: ERP technical competences are positively related to the business process performance.

ERP human competences is a multifaceted construct that refers to the managerial knowledge, expertise, and skills that organizations possess that are used to manage the ERP systems projects (Stratmen & Roth, 2002). These competences involve understanding the business processes requirements and the consequences of BPR, understanding the role of ERP systems in supporting business strategies, managing ERP systems, and fulfilling the needs of the users of ERP systems. Therefore, ERP human competences will enhance all the stages of ERP systems implementation and creating better alignment of the systems and the business process that results in enhanced business process performance. This leads to the following hypothesis:

H_2: ERP human competences are positively related to the business process performance.

The Complementarity between Human and Technical Competences

Complementarity describes the enhancement of a resource and its ability to produce greater return to the organization in the presence of another complementary resource (Zhu, 2004; Migrom & Roberts, 1995; Barua et al., 2000). Technical and human

competences complement each other and create synergies that lead to enhanced ERP systems performance. For instance enhancing strategic ERP planning, which is a technical competency will entail the organization to collect and use information to create new knowledge on ERP strategy. However, this process will also enhance managerial competences related to how to fill in the knowledge gap of the organization which is necessary for better ERP systems implementation. While the two competences contribute individually to the performance of business process, the synergy between the two resources will have an incremental contribution. If duplicating the ERP human and technical competences by firms is not an easy process, duplicating the synergy between these two competences is even more difficult due to the path-dependent process that will involve time, complex resources and capabilities to build (Zhu, 2004). Drawing on H_1 and H_2, this lead to the following hypothesis:

H_3: The Complementarity between ERP human and technical competences are positively related to the business process performance.

Business Process Performance and Organizational Performance

First-order business processes benefits are the leading indicators of organizational competitive benefits (Elbashir et al., 2008). An organization's performance impact of ERP systems depends on the effectiveness of the ERP system in facilitating the business processes redesign and generating both the operational efficiency and effectiveness benefits (Subramani, 2004; Ray et al., 2005). Organizations that generate greater benefits from their ERP system investments across their business processes will be able to generate organizational performance. Consistent with the two-stage model of benefits suggested in prior literature (Elbashir et al., 2008; Melville et al., 2004; Subramani, 2004), business processes benefits from ERP systems are expected to enhance the organizational-level performance (sales growth, profit margin, ROI). This leads to the following hypothesis:

H_4: Business process performance impact of ERP systems are positively related to the organizational-level performance.

Control Variables

We include the firm size and ERP systems sophistication constructs as control variables in the research model to discount rival hypotheses that relate to firm-specific factors driving the performance impact of ERP systems at business processes and organizational levels.

Firm size is used in prior IS literature to proxy for the size of the organization resource base that can enhance ERP performance (Zhu, 2004; Subramani, 2004). Large firms are more able to invest speculatively in different ERP systems supporting activities and resources such as employee training (Chatterjee et al. 2002; Subramani 2004). We use the logarithm of the total assets as the proxy for firm size (Melville et al. 2004).

ERP systems sophistication is included in the research model to capture the level of organization's deployment of ERP systems modules. Organizations that implement more

ERP systems module may have a better chance to achieve business value. This is because increased ERP systems models will support a larger proportion of the business processes (Armstrong & Sambamurthy, 1999). We use the number of ERP systems modules implemented by the organization (e.g. financial, HR, and inventory management.) to capture the level of ERP systems sophistication.

Research Design

Data was gathered through a large survey that targeted 421 Chinese companies, which have adopted ERP systems between 1999 and 2007, that are listed in Shanghai and Shenzhen Stock Exchanges. Multiple responses were solicited from each organization at different managerial levels including CFO, CIO and ERP systems users. This strategy enabled the collection of rich data while eliminating biased responses (Huber & Power, 1985; Sethi & King, 1994). 215 responses were received from 65 organizations to realize a response rate of 15%. The average response of the multiple responses is used to represent the organization.[1] An ANOVA test was conducted to test for non-response bias. Early and late responses were compared in paired samples of 10 and 20 responses. The results show that there were no significant differences ($p < .05$) on any of the variables of the study. We also conducted Harman's one-factor common method test (Podsakoff & Organ, 1986). The results show neither a single factor emerged from the exploratory factor analysis nor did one general factor account for the majority of the variance in the measurement items used in the model.

Table 1 displays the descriptive statistics of 65 companies that responded to the survey. The surveyed companies are medium to large enterprises with a mean of 988 million Yuan in total assets. More than 50% of respondents' age falls between 36-45% and about 50% of the respondents have 11-15 years of work experience.

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[1] Following Armstrong and Sambumurthy 1999, we used correlations among the responses of multiple respondents on the main constructs of the study to test for consistency among respondents of the same organization. The results show that all the correlations are positive and significant at the 1% level of significance.

Table 1: The Questionnaire and Descriptive Statistics (65 Listed Companies)

Initial issue	Measurement
ERP Software Category (based on UFIDA classification)	
Financial Accounting	65 (100%)
Management Accounting	13 (20%)
Supply Chain Management (SCM)	21 (32.31%)
Customer Relationship Management (CRM)	12 (18.46%)
Manufacturing and product management	16 (24.62%)
Human Resource Management (HRM)	13 (20%)
Office automation (OA)	26 (40%)
Decision Support System	4 (6.16%)
Group Management	7 (10.76%)
Internet sales	4 (6.15%)
Enterprise Application Integration	5 (7.70%)

	N	Mean	Std.	Min	Max
Total assets (Yuan in Million)	65	988.10	849.33	106.33	2354.34
Age*	215	2.49	0.59	1	3
Less than 25 years old	10(4.7%)				
26-35 years old	87(41.3%)				
36-45 years old	116(54%)				
Work Experience **	215	2.56	0.91	1	4
Less than 5 years	36(16.7%)				
6-10 years	49(22.8%)				
11-15 years	105(48.4%)				
More than 15 years	28(12.1%)				

* On the questionnaire, Age = 1, if younger than 25 years old, = 2 if aged 26 to 35 years old, = 3 if aged 36 to 45 years old.

** On the questionnaire, Work experience = 1, if less than 5 years, = 2, if 6 to 10 years = 3, if 11 to 15 years, = 4 if more than 15 years.

Operationalization of the Constructs

Organizational Performance is a high-order construct which refers to overall firm performance which is captured at the financial and non-financial dimensions. 18 items were adapted from prior studies to measure these two dimensions whereby ten items relate to financial and eight items to non-financial dimensions (Shang & Seddon, 2000; Kaplan & Norton, 1992; Melville et al., 2004; Mukhopadhyay & Kekre, 2002). The confirmatory factor analysis (CFA) test supports the use of 12 items, six of them loads on non-financial dimension and the remaining six items loads on the financial dimensions of firm performance. The measurement items for the organizational performance measure are reported in Appendix A.

Business processes performance of ERP systems refers to the performance outcome of ERP systems at the business process level that is attributable to the contribution of the systems to enable the BPR. Business process performance is operationalized as a second-

order construct using eight items that capture two dimensions of BPR benefits, *cost rationalization* and *work restructure* (Lawler et al., 2001; Ramirez et al., 2010). The CFA supports the use of seven items, three for cost rationalization and four for work restructuring. (See Appendix A).

ERP systems competences refer to a portfolio of managerial and technical skills and expertise that are necessary for enabling the deployment of ERP systems to enhance the business process of the organization (Stratman & Ruth, 2002). ERP systems competences are conceptualized as a high-order construct with two second-order dimensions that are proposed by Stratman and Roth (2002): (1) ERP systems technical competences, which are measured with 40 items that capture the following four first-order dimensions of technical competences: ERP training, IT skills, strategic ERP planning, and executives commitment; (2) ERP systems human competences, which are measured with 39 items that capture four first-first order dimensions human competences: business process skills, learning, change readiness, and project management. Consistent with prior studies (e.g. Elbashir et al., 2011), we created four composite variables for each of the two ERP systems competences by averaging the respondents' score for each of the four dimensions of the two ERP competences. The measurement items of the ERP systems technical and human competences are reported in Appendix A.

The initial draft of the measurement items included in the instrument was validated using feedback and comments received from a group of ERP experts who work at a leading ERP software company in Asia-Pacific region. This was followed by a pilot test that was conducted with ten senior executives including financial managers and CIOs who were asked to answer the survey and comment on its content and structure. The feedback at the pilot test stage was incorporated in the final draft of the survey. The final list of the measurement items are shown in Appendix A. The final survey version was translated into Chinese (Mandarin) language using expert translator. To ensure the accuracy of the translation, the Chinese-translated version of the survey was retranslated by another expert to English. Then, the translated version was compared with the original English version. The results of the comparison show no difference between the meanings of the same questions in the two versions of the survey.

DATA ANALYSIS AND RESULTS

Partial Least Square (PLS) was used to test the properties of the scales used to measure the constructs (measurement model) and examine the strength of the relations between the constructs (structural model). PLS is the most suitable structural equation modeling (SEM) technique compared to other SEM techniques such as LISREL. This is due to the small sample size used in this study and the formative constructs tested in the research model (Gefen et al., 2000; Chin et al., 2003).[2] The bootstrap resampling

[2] We have tested for possible multicollinearity in relation to the measurement items of the formative constructs (technical and human). The variance inflation factor (VIF) scores for the items of the formative measures are between 2 and 4 which are within the acceptable range (Petter et al. 2007). These results indicate that multicollenarity does not represent any major threat to the validity of results reported in this study.

method (1000 samples) in PLS was used to estimate the t-value, which determines the significance of the path coefficients.

Properties of the Measurement Model

Multiple tests, suggested in prior studies, were performed to assess the construct validity and reliability (Churchill, 1979; Straub, 1989). The output from PLS in relation to the measurement model was used to examine the properties of the measures including internal consistency and the convergent and discriminant validity of the measurement items. Items that loaded 60% or above were retained in the measurement model (Hulland, 1999). We use the indicator weight rather than loading to test the formative construct validity.

Reliability refers to the extent to which the measurement items used are consistent in what they intend to measure (Straub, 1989; Hulland, 1999; Zhu and Kraemer 2002). Table 2 shows the composite reliability for all constructs are above the cut-off of 0.70 (Nunnally, 1978). This indicates that all the constructs measures have very good reliability (DeVellis, 1991).

Content validity: The construct measures used in the study are supported by the prior literature and represent the domains that they were intended to measure (Carmines & Zeller, 1979). Subsequent tests including a pilot test that used peers and experts' opinion were conducted to add to the confidence the researchers placed on the content validity of the measures.

Convergent validity examines whether measures that should be related are related (Hair et al., 1998). Item loading together with the average variance extracted (AVE) were used in the study to examine the convergent validity of the constructs that are measured with reflective items (Straub, 1989). Table 1 shows that all the items have significant loadings, which indicate their significant contribution to the measured construct. Moreover, AVE for all the constructs are above 0.50 which demonstrates the convergent validity of the measurement items (Fornell & Larcker, 1981). This also indicates that each of the measured constructs explain more than 0.50 of the variation in the observed variables.

Table 2: Individual Item Loadings, Composite Reliability, Average Variance Extracted (AVE) Statistics

Dimensions of Firm performance			
1. The Financial Dimension of Firm Performance: (Composite Reliability = 0.91, AV E = 0.62)			
Measurement Items	**Loading**	**Standard Error**	***T*-Statistics**
PEFI1: Operating income	0.819	0.044	18.602
PEFI2: Sales growth rate	0.790	0.049	16.047
PEFI3: Return on investment (ROI)	0.854	0.029	29.533
PEFI4: Return on assets (ROA)	0.811	0.056	14.397
PEFI5: Operating return on assets (OIA)	0.761	0.062	12.236
PEFI8: Selling, general and administrative expenses over sales (SGAS)	0.662	0.080	8.279
2. The Non-Financial Dimension of Firm Performance: (Composite Reliability = 0.86, AV E = 0.52**)**			
PENF2: Ratio of good output to total output at each production process	0.658	0.082	8.066
PENF3: Manufacturing lead time	0.750	0.061	12.197
PENF4: Rate of material scrap loss	0.835	0.041	20.370
PENF5: Labor efficiency variance	0.762	0.051	15.065
PENF6: Number of new patents	0.633	0.124	5.099
PENF10: Personnel development	0.648	0.080	8.114
Dimensions of Business Process Performance			
1. Work restructure Benefits: (Composite Reliability = 0.89, AV E = 0.66)			
PEBP1: Process simplification	0.770	0.063	12.182
PEBP2: improve the coordination among different units of the firm	0.856	0.032	26.867
PEBP3: Major information system redesign	0.831	0.040	21.042
PEBP4: Enriched multi-skilled individual jobs	0.798	0.044	18.295
2. Cost rationalization Benefits: (Composite Reliability = 0.81, AV E = 0.59)			
PEBP5: The efficiency and productivity of business processes	0.793	0.058	13.713
PEBP6: Doing the same work with fewer people	0.761	0.053	14.490
PEBP7: Doing the same work with less supervision	0.754	0.067	11.192

Dimensions of ERP Systems Competences			
A. **Human Competences:** (Formative measures)			
	Weight	Standard error	T-statistics
1. ProMgt: Project management	0.226	0.230	0.982
2. BPSkills: Business process skills	0.403	0.263	1.533
3**. Learn:** learning	0.116	0.179	0.645
4. ChangeRead: change readiness	0.863	0.100	8.662
B. **Technical Competences:** (Formative measure)			
	Weight	Standard error	T-statistics
1. Train: Training	0.308	0.214	1.440
2. ITSkills: IT skills	0.948	0.084	11.282
3. StratItPlan: Strategic IT planning	0.484	0.201	2.412
4. ExecutCom: Executive commitment	0.465	0.187	2.490

Table 3: Inter-Construct Correlations and Square Root of Average Variance Extracted Statistics (n=65)

	1	**2**	**3**	**4**
1. Financial	**0.79**			
2. Non-financial	0.69	**0.72**		
3. Cost rationalization	0.70	0.71	**0.77**	
4. Work restructure	0.70	0.69	0.73	**0.81**

Diagonal elements are the square roots of the average variance extracted statistics. Off-diagonal elements are the correlations between the latent variables calculated in PLS.

Discriminant validity examines the relationship between measures of similar and different constructs to provide more evidence that the scales used are measuring distinct constructs. Table 3 shows that the values of the square root of the AVE (on the diagonal) are all greater than the inter-construct correlations (off the diagonal). This demonstrates that the measures exhibit satisfactory discriminant validity.

Table 4: Measurement Items Loading and Cross-loading

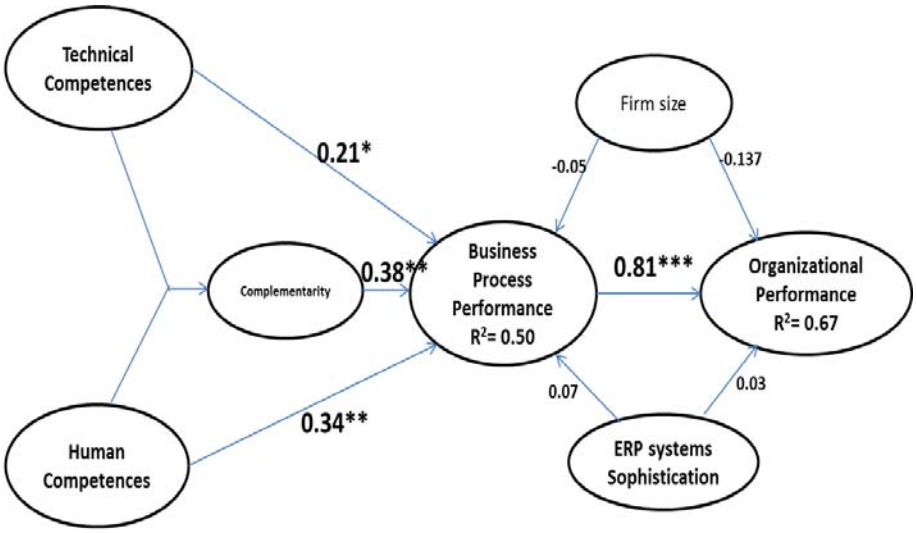
	Financial	**Non-financial**	**Work restructure**	**Cost rationalization**
PEFI1	**0.819**	0.564	0.537	0.655
PEFI2	**0.790**	0.488	0.477	0.445
PEFI3	**0.854**	0.557	0.540	0.575
PEFI4	**0.811**	0.638	0.553	0.504
PEFI5	**0.761**	0.494	0.570	0.566
PEFI8	**0.662**	0.522	0.662	0.580
PENF2	0.493	**0.658**	0.536	0.623
PENF3	0.413	**0.750**	0.544	0.562
PENF4	0.547	**0.835**	0.540	0.607
PENF5	0.557	**0.762**	0.536	0.466
PENF6	0.460	**0.633**	0.389	0.354
PEBP1	0.545	0.512	**0.770**	0.601
PEBP2	0.629	0.598	**0.856**	0.614
PEBP3	0.622	0.554	**0.831**	0.576
PEBP4	0.486	0.585	**0.798**	0.589
PEBP5	0.544	0.540	0.509	**0.793**
PEBP6	0.614	0.628	0.614	**0.761**
PEBP7	0.460	0.453	0.557	**0.754**

An additional test of discriminant validity was also conducted in this study. All measurement items were assessed to ensure that each measurement item has a higher loading on its assigned factor than on the other factors (Chin, 1998; Gefen et al., 2000). The results are presented in Table 4. Each of the measurement items loaded higher on the appropriate construct than on the other constructs (Chin, 1998; Gefen et al., 2000). These results provide further support for the adequacy of discriminant validity of the measures used in this study.

Results

The test of the structural model involves estimating the path coefficients that link between the latent variables under investigation and R^2, which represents the amount of the variation in the dependent variables that is explained by the independent variables (Wixom & Watson, 2001). Overall, the result suggests the model has good predictability. The coefficients for all paths between the constructs tested in the model are significant and above 0.21. The results also indicate that 67% of the variance in organizational performance and, 50% of the variance in business process performance are explained by the model.

Figure 2: Path Coefficients and R^2 Values of the Structural Model of ERP systems Payoff



Significance of the Control Variables

The results regarding the control variables are summarized in Panel B of Table 5. Surprisingly none of the control variables are significantly related to business process or organizational performance. In particular, the result fails to support the theoretical argument of prior IT payoff studies that firm size and the level of IT sophistication enhance organizational performance. One plausible explanation is that the effect of firm size and the level of IT sophistication are better captured by ERP systems competences that are included in the model.

Table 5: Panel B: Control Variables

Panel A: Path/Hypothesis	**Path Coefficient**	**T- value**
ERP Technical Competences ---> Process Performance	0.209	1.892*
ERP Human Competences --- -> Process Performance	0.343	3.189**
Business Process Performance ----> Organizational Performance	0.810	16.393***
Panel B: Control Variables		
Firm size ---> Business Process Performance	-0.051	0.542
Firm size ---> Organizational Performance	-0.137	1.740
ERP Sophistication ---> Business Process Performance	0.069	0.745
ERP Sophistication ---> Organizational Performance	0.026	0.324

***** Indicates that the coefficient is significant at the $p < .05$
** Indicates that the coefficient is significant at the $p <. 01$
*** Indicates that the coefficient is significant at the $p <. 001$

Hypothesis Testing

Hypotheses were tested within the structural equation model shown in Figure 1 based on the magnitude and significance of path coefficients estimated using PLS. The hypothesis that posit the complementarity between technical and IT resources was tested by using the incremental change in R^2 due to the introduction of the interaction term in addition to the magnitude of the interaction term's path (Zhu, 2004).

In H_1 and H_2, we predict that the ERP systems technical and human competences will be positively associated with the business process performance. The results shown in Figure 2 and Table 5 support the two hypotheses with strong and significant direct relationships. The coefficients of the structural path were 0.21 ($p < .0.05$) and 0.34 ($p < .0.01$), respectively. This result supports the theorization that improvement in ERP systems technical and human competences, have a positive influence on the business processes performance.

Table 6: Test of the Complementarity

Model	Independent Variable	Business Process Performance	
		Coefficient	R^2
Model 1:			37%
	Human competences	0.43	
	Technical competences	0.27	
Model 2: (Figure 2)			50%
	Human competences	0.34	
	Technical competences	0.21	
	Complementarity	0.38	
Increase in R^2 Model 1 vs. Model 2			13%

In H_3, we predict that the complementarity between ERP systems technical and human competences is positively associated with the business process performance. The basic premise underlying the research model is that the research model with the complementarity between technical and human competences is superior to the alternative research model without the complementarity. We tested the two models and compared the results (Table 6). As shown by the increase in R^2, our research model using the Complementarity has superior predictive value of business process performance when compared to the models that only capture the main effects of the two ERP systems competences separately. The magnitude of the relationship between the complementarity and business process performance provides further evidence of the importance of dually developing technical and human competences in order to leverage the value of ERP systems at the business process level. The variance explained in the business process performance construct as the result of the introduction of the interaction term has increased by 13% (from 37% to 50%), while the coefficient of the structural paths leading from the Complementarity to business process performance was 0.38. This result supports the theorization that the strength of the Complementarity has a positive influence on the business processes performance.

H_4, examines whether business process performance impacts organizational performance. The results shown in Figure 2 and Table 5 support H_4 (0.81, $p < 0.001$). These findings support the theorization that improvements in business process performance translate into improved organizational performance.

Following the test for the direct effects in our model, we examined the indirect effect of the ERP systems competences on organizational performance via business process performance. As noted in the theory section, the business process performance is viewed as being driven by the level of the ERP systems competences that the organizations build over time. We estimate the path coefficients of the indirect effects using the product term of the coefficients of the associated direct paths. We used bootstrap procedures to construct 95 percent ($p < 0.05$) confidence intervals for testing the significance of the indirect effects (Hayes 2009). The indirect effects and total effects are reported in Table 7.

Table 7: Indirect Effects and 95% Bootstrap Confidence Interval

ERP human competences -----< Business process performance ---- < organizational performance	0.28 (-0.085 - 0.455)
ERP technical -----< Business process performance ----- < organizational performance	0.17(-0.103 – 0.433)

The results show that the technical competences indirectly affect organizational performance through business process performance (0.17, $p < 0.05$). The human competences are also significantly indirectly related to organizational performance through business process performance (0.28, $p < 0.05$). These results indicate that ERP systems competences contribute directly to the business process performance and indirectly to organizational performance.

We also conducted the mediation test suggested by Baron and Kenny (1986) to examine whether business process mediates the relation between the two ERP competences and organizational performance.[3] The results of the tests indicate that the business process performance fully mediates the relations between ERP systems technical and human competences and organizational performance.

DISCUSSION, CONCLUSION AND IMPLICATIONS

This study aims to improve our understanding on how ERP systems resources promote firm performance. The study synthesizes perspectives from the process-oriented and resource-based view literature in order to propose and test an integrated research model of the business value of ERP systems. Drawing on the process-oriented view, the study posits that business process performance is an important stage towards achieving enhanced organizational performance. The empirical data provided a strong support for the hypotheses suggested in the research model.

We hypothesized that ERP systems competences represented by technical and human competences are important antecedents of ERP business value. Our path analysis results show that both ERP human and technical resources directly relate to business process performance. Further, they indirectly affect organizational performance through business process performance. The findings imply that developing ERP competences is a resource-intense, path-dependent process that requires skilled personnel as well as a wide range of relevant IT components. The result of this study suggests that organizations that

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[3] We followed the four steps suggested by Baron and Kenny (1986) to test the extent to which business process performance mediates the relation between the two ERP systems competences and organizational performance: (1) Test that ERP systems competences predicts organizational performance. (2) Test that ERP systems competences predicts business process performance. (3) Test that ERP systems competences and business process performance are simultaneously predict organizational performance. (4) Test that business process performance mediates (completely or partially) the relation between ERP competences and organizational performance.

have developed ERP competences should have the necessary ERP resource foundations that enable them to exploit the implemented ERP systems in their business strategies and activities. ERP technical and human competences are found to have a significant impact on business process and organizational performance.

This study makes several contributions. First, the study represents an important attempt to open the "black box" of ERP systems investments and understand the mechanisms through which ERP systems create business value. A large number of studies have investigated the relation between ERP systems investments and ERP systems payoff. However, when it comes to the question of how organizations create such value from ERP systems, the literature falls short. Therefore, a theory explaining how investments in ERP systems can be turned into organizational performance is an outstanding challenge to the AIS community. The resulting analysis presented in this study serves to explain why some organizations are able to leverage their ERP systems investments and generate a higher competitive advantage than others. Business process performance related to BPR, which has not been examined adequately in prior literature, is found to be a major driver of organizational performance. This finding suggests future ERP systems payoff studies should capture BPR and business process performance in the research model. Second, the study provides evidence that ERP technical and human competences are important antecedents for the successful deployment of ERP systems. In order to further enhance ERP systems performance, organizations need to develop these competences and create a synergy between these resources. Third, despite the growing literature of the business value of ERP systems, there is a dearth of research that tests the link between the business process and organizational performance of ERP systems. This study links the two performance outcomes by examining a research model that predicts a relation between the business process performance impact of ERP systems and organizational performance. In doing so, the study argues that acquiring and developing high quality ERP systems software applications is not necessarily sufficient for organizations to create business value (Mata et al., 1995; Carr, 2003). Business value from ERP systems is determined by the business process performance impact that organization accrue from using these systems (Parsons, 1983; Porter & Millar, 1985; Armstrong & Sambamurthy, 1999; Piccoli & Ives, 2005).

Finally, the study provides some insights regarding the claim that "IT Doesn't Matter" (Carr, 2003) that was made in prior IT payoff studies. Failing to differentiate between ERP systems and ERP competences, which represent the organization's ability to exploit ERP systems, is a fundamental flaw that may lead businesses to make the erroneous conclusion that "IT doesn't matter." Developing high quality ERP competences is path dependent and takes a longer time. Therefore, organizations should continue investing in ERP competences, including technical and managerial knowledge and skills that convert ERP systems investments into capabilities that are fundamental for successful business strategies.

Limitations

The findings of this study should be considered in the light of its inherent limitations. First, the findings are based on self-reported data, which may be subject to common method variance or potential respondent "self-selection" bias. However, the multiple tests (reliability and CFA) and the good psychometric properties reported in the study support the validity of the results. Moreover, capturing data from multiple respondents of

the same organization may be viewed as offsetting any respondents' bias. Prior studies also found that senior and middle managers' perception to be a good proxy for organizational performance (Dess & Robinson, 1984; Mahmood & Soon, 1991; Sethi & King, 1994; Tallon et al., 2000; Zhuang & Lederer, 2003). Future research can extend this study by using archival data instead of survey data, time series data, objective performance measures, quantifying the organizational structure and culture changed as the result of the ERP implementation, and adopting a field or case study methodology.

Second, the model suggests causal relations and multistage performance (i.e. process performance, and then organizational performance) while using cross sectional data, which only allows testing for the association between the variables of the research model. As the study attempts to understand a complex phenomenon in a natural setting and generalize the findings, the experimental method may not be the best option. Future research should consider using longitudinal data.

Third, the study did not capture the size of organizations' investments in ERP systems, which might have some influence on the level of organizational performance impact of ERP systems. However, the study includes a control variable to capture the number of ERP modules used by the firm, which can represent the level of the organizations' maturity with ERP systems and the level of investment.

Fourth, the study did not control for factors that may moderate the relation between business processes benefits and organizational performance such as competitive response and environmental change. This is an area for future research.

In summary, the empirical results reported in this study provide explanations for some of the inconsistencies in the findings reported in prior ERP payoff studies. The study clearly differentiates between ERP infrastructure as the ERP foundation and ERP competences that enable the deployment of the ERP infrastructure to support business process and functions. The result shows that business process performance is an important variable, and when included the explanatory power of the model increase significantly. The findings also demonstrate a positive indirect relation between ERP competences and organizational performance via business process performance.

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Appendix A

Please indicate the extent to which you agree or disagree with each of the following statements by circling the relevant number (1= strongly disagree and 7 = strongly agree):

Technical ERP Resources:

Strategic IT Planning

1. We constantly review our IT capabilities against strategic goals.	1	2	3	4	5	6	7
2. IT plans are redesigned as required to meet evolving conditions.	1	2	3	4	5	6	7
3. Strategic IT planning is a continuous process.	1	2	3	4	5	6	7
4. Written guidelines exist to structure strategic IT planning in our organization.	1	2	3	4	5	6	7
5. Top management is not involved in strategic IT planning. (reversed coded)	1	2	3	4	5	6	7
6. Strategic IT planning includes inputs from all functional areas.	1	2	3	4	5	6	7
7. The business impact of proposed ERP system changes is not evaluated against strategic goals.	1	2	3	4	5	6	7
8. IT plans for functional areas are driven by the overall ERP Entity IT plan	1	2	3	4	5	6	7
9. IT planning is driven by the ERP Entity`s strategic business plan.	1	2	3	4	5	6	7

Executive Commitment

1. Functional managers willingly assign resources to the ERP project as they are needed.	1	2	3	4	5	6	7
2. The need for long-term ERP support resources is recognized by management.	1	2	3	4	5	6	7

3. Executive management is enthusiastic about the possibilities of ERP.	1	2	3	4	5	6	7
4. Executives have invested the time needed to understand how ERP will benefit the enterprise.	1	2	3	4	5	6	7
5. Executives mandate that ERP requirements have priority over unique functional concerns.	1	2	3	4	5	6	7
6. Top management has clearly defined commitments. the ERP Entity's business goals.	1	2	3	4	5	6	7
7. All levels of management support the overall goals of the ERP Entity.	1	2	3	4	5	6	7
8. Employees who support the ERP project are distracted by other commitments.	1	2	3	4	5	6	7

IT Skills

1. The internal IT staff have the ability to conduct routine ERP system maintenance.	1	2	3	4	5	6	7
2. There is a high degree of technical expertise in the IT organization.	1	2	3	4	5	6	7
3. The database administrator is an expert in the ERP database management system.	1	2	3	4	5	6	7
4. Internal IT team members understand custom ERP software programs.	1	2	3	4	5	6	7
5. The IT staff are able to efficiently implement ERP system upgrades.	1	2	3	4	5	6	7
6. The IT staff have the technical ability to conducta formal validation of all system changes.	1	2	3	4	5	6	7
7. IT staff are able to analyze the technical impact of proposed system changes.	1	2	3	4	5	6	7
8. The IT staff actively builds relationships with business managers.	1	2	3	4	5	6	7

9. IT staff offer ideas on how IT can be used to achieve business goals.	1	2	3	4	5	6	7
10. IT staff communicate with functional use							
ERP Training							
1. Specific user training needs were identified early in the implementation.							
2. A formal training program has been developed to meet the requirements of ERP system users.							
3. Training materials have been customiz for each specific job.							
4. We seldom update training materials to ref system changes.	1	2	3	4	5	6	7
5. Training materials target the entire busines task, not just the ERP screens and reports.							
6. Employees are tracked to ensure that they have received the appropriate ERP system training.							
7. All users have been trained in basic ERP system skills.							
8. ERP system training review sessions are scheduled.							
9. The training needs of each user group have been identified.							
10. Training is conducted by consultants.							
groups in the ERP Entity.							
11. The IT organization provides a service to the business.	1	2	3	4	5	6	7
12. IT project members have limited ERP software expertise.	1	2	3	4	5	6	7
13. IT staff are not responsive to the needs of business managers.	1	2	3	4	5	6	7

Human ERP Resources:

Business Process Skills

1. There is a high level of business process knowledge within the ERP Entity.	1	2	3	4	5	6	7
2. Employees understand how their actions impact the operations of other functional areas.	1	2	3	4	5	6	7
3. Employees understand how their daily business activities support the goals of the ERP Entity.	1	2	3	4	5	6	7
4. Managers are not clear on how ERP-focused business processes support the goals of the ERP Entity.	1	2	3	4	5	6	7
5. The operational processes of the ERP Entity are formally documented.	1	2	3	4	5	6	7
6. Our ERP Entity's business process documentation reflects actual operational activities.	1	2	3	4	5	6	7
7. Functional managers are able to document cross-functional business process flows.	1	2	3	4	5	6	7
8. Business process design is driven by customer requirements.	1	2	3	4	5	6	7
9. Managers are skilled at analyzing business processes for customer benefits.	1	2	3	4	5	6	7

Learning

1. Benchmarking is used to identify cutting-edge ERP techniques.	1	2	3	4	5	6	7
2. We keep track of ERP developments related to our industry.	1	2	3	4	5	6	7
3. Cross-functional groups meet regularly to discuss new uses for the ERP system.	1	2	3	4	5	6	7
4. Internal groups meet regularly to share new methods of using the ERP system.	1	2	3	4	5	6	7

5. ERP improvement suggestions are regularly collected from multiple employee levels.	1	2	3	4	5	6	7
6. Business experiments are conducted to evaluate potential improvements in the way we use ERP.	1	2	3	4	5	6	7
7. ERP experimentation is encouraged even if the proposed improvement is unsuccessful.	1	2	3	4	5	6	7
8. External ERP experts are invited to suggest better ways to use the ERP system.	1	2	3	4	5	6	7
9. Users are discouraged from exploring alternative methods of using ERP to generate business value.	1	2	3	4	5	6	7
10. The potential customer benefit of new ERP techniques is not formally evaluated.	1	2	3	4	5	6	7

Change Readiness

1. Employees understand how they fit into the new ERP Entity.	1	2	3	4	5	6	7
2. Employees have input into how their jobs will change with new ERP business processes.	1	2	3	4	5	6	7
3. Management actively works to alleviate employee concerns about ERP.	1	2	3	4	5	6	7
4. An ERP support group is available to answer concerns about ERP job changes.	1	2	3	4	5	6	7
5. The roles of all employees under the ERP system have been clearly communicated.	1	2	3	4	5	6	7
6. The change readiness of employees impacted by the ERP system is regularly assessed.	1	2	3	4	5	6	7
7. Employees are not prepared for a series of ERP-related changes as the system evolves.	1	2	3	4	5	6	7

8.	ERP-focused changes to the employee reward system have been communicated.	1	2	3	4	5	6	7
9.	Employees recognize the need for organizational change.	1	2	3	4	5	6	7

Project Management

1.	The tasks to be performed during the ERI are clearly defined.	1	2	3	4	5	6	7
2.	The responsibilities of project team mem clearly defined.	1	2	3	4	5	6	7
3.	There is a formal management process external contractor activities.	1	2	3	4	5	6	7
4.	Problems found during reviews of externa members are not tracked to closure.	1	2	3	4	5	6	7
5.	Measurements are used to determine the s project tasks.	1	2	3	4	5	6	7
6.	Project tasks are reviewed on a periodic bas	1	2	3	4	5	6	7
7.	The ERP project leader is able to track tasks to completion.	1	2	3	4	5	6	7
8.	The ERP project leader is experienced in management.	1	2	3	4	5	6	7
9.	Project tasks are reviewed on an even basis.	1	2	3	4	5	6	7
10.	The relative priority of different categ change requests are not documented.	1	2	3	4	5	6	7
11.	Resources are assigned to ERP system requests according to prioritization rules.	1	2	3	4	5	6	7
12.	ERP project tasks are tracked against p business benefits.	1	2	3	4	5	6	7

Business Process Performance

1.	Process simplification	1	2	3	4	5	6	7
2.	improve the coordination among different units of the firm	1	2	3	4	5	6	7
3.	Major information system redesign	1	2	3	4	5	6	7
4.	Enriched multi-skilled individual jobs	1	2	3	4	5	6	7
5.	The efficiency and productivity of	1	2	3	4	5	6	7

	business processes							
6.	Doing the same work with fewer people	1	2	3	4	5	6	7
7.	Doing the same work with less supervision	1	2	3	4	5	6	7
8.	A lower overall cost structure.	1	2	3	4	5	6	7

Non-financial performance

1.	Materials efficiency variance	1	2	3	4	5	6	7
2.	Ratio of good output to total output at each production process	1	2	3	4	5	6	7
3.	Manufacturing lead time	1	2	3	4	5	6	7
4.	Rate of material scrap loss	1	2	3	4	5	6	7
5.	Labor efficiency variance	1	2	3	4	5	6	7
6.	Number of new patents	1	2	3	4	5	6	7
7.	Number of new products launches	1	2	3	4	5	6	7
8.	Time-to-market new products	1	2	3	4	5	6	7
9.	Employee satisfaction	1	2	3	4	5	6	7
10.	Personnel development	1	2	3	4	5	6	7

Financial performance

1.	Operating income	1	2	3	4	5	6	7
2.	Sales growth rate	1	2	3	4	5	6	7
3.	Return on investment (ROI)	1	2	3	4	5	6	7
4.	Return on assets (ROA)	1	2	3	4	5	6	7
5.	Operating return on assets (OIA)	1	2	3	4	5	6	7
6.	Cash flow from operation	1	2	3	4	5	6	7
7.	Cost of goods sold divided by	1	2	3	4	5	6	7

	sales (CGSS)							
8.	Selling, general and administrative expenses over sales (SGAS)	1	2	3	4	5	6	7

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