REINVESTIGATING THE RELATIONSHIP BETWEEN INFORMATION TECHNOLOGY CAPABILITY AND FIRM PERFORMANCE: FOCUSING ON THE IMPACT OF THE ADOPTION OF ENTERPRISE SYSTEMS

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Abstract

Though many information systems researchers have made various attempts to investigate the relationship between information technology capability and firm performance from diverse perspectives, we have not come to a conclusion yet with some mixed results. In this research, focusing on the adoption of Enterprise Resource Planning systems by firms as a proxy measure of information technology capability, we re-examine whether the association is positive or negative. With the sample of Korean firms which have adopted Enterprise Resource Planning (ERP) systems in 2009, we match ERP adopters and non-adopters with propensity score matching, and compare financial performance between them with difference-in-difference estimation between pre- and post-adoption period. According to our analysis, we find out that there is no positive and significant relationship between information technology capability and firm performance in profit ratios. This research shows that contrary to the era of propriety information systems, standardized information systems make no more competitive advantages against competitors these days.

Keywords: Information technology capability, Firm performance, Enterprise systems, ERP systems

1 INTRODUCTION

A lot of information systems (IS) researchers have made attempts to examine the relationship between information technology (IT) capability and firm performance. To explain IT capabilities of firms, prior researchers have paid attention to Enterprise Systems (ES). ES can be defined as "commercial software packages that enable the integration of transaction-oriented data and business processes throughout an organization (and perhaps eventually throughout the entire interorganizational supply chain)" (Markus & Tanis 2000). In their definition, ES can include "ERP software and such related packages as advanced planning and scheduling, sales force automation, customer relationship management, and product configuration" (Markus & Tanis 2000).

Though some researchers argued there is positive relationship between IT capability and firm performance (Bharadwaj 2000; Hitt et al. 2002; Santhanam & Hartono 2003), other researchers revealed that there is no significantly positive relationship between them (Chae et al. 2014; Hendricks et al. 2007; Shin 2006). Regarding new trend in the adoption of enterprise applications, Shin (2006) pointed out that companies come to purchase over-the-self enterprise application software, not developing their information systems in house. As companies come to adopt standardized ES in 2000s, recent study argued that firms come to face challenges in making differentiated advantages from their competitors with ES (Chae et al. 2014).

In other words, the relationship between IT capability and firm performance is an on-going research topic for IS researchers. In this regard, the objective of this paper is to re-examine whether IT capability really makes a positive influence on firm performance these days. Specifically, with the sample of Korean companies which adopted Enterprise Resource Planning (ERP) systems, we attempt to investigate whether the adoption of the enterprise application can contribute to enhancing firm performance substantially between pre- and post-adoption period.

2 LITERATURE REVIEW

Although a lot of IS researchers have investigated the association between IT capability and firm performance, we still have no absolute conclusion. Some researchers emphasized the positive impacts of IT capability on firm performance (Bharadwaj 2000; Hitt et al. 2002; Santhanam & Hartono 2003), while other researchers pointed out there is insignificant or mixed relationship between them (Chae et al. 2014; Hendricks et al. 2007; Shin 2006).

Using a matched sample comparison with IT leaders and control companies, Bharadwaj (2000) investigated the relationship between IT capability and firm performance, and showed that IT capability makes a positive influence on firm performance. Extending the matched sample comparison method by Bharadwaj (2000), Santhanam and Hartono (2003) considered average performance of all firms in the industry as a control group and reconfirmed the positive relationship. Meanwhile, focusing on IT capability in terms of ERP adoption, Hitt et al. (2002) revealed that ERP adopters show higher performance in various measures than non-adopters.

However, not all of researchers agree to the positive association between IT capability and firm performance. In the most recent study, Chae et al. (2014) argued that unlike the era of proprietary information systems in 1990s, standardized ES in 2000s can't make strategic advantages for ES adopters. In addition, several studies found some mixed results on the relationship of IT capability and firm performance. With six enterprise application software packages such as ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), SCM (Supply Chain Management), KM (Knowledge Management), GW (GroupWare), and EAI (Enterprise Application Integration), Shin (2006) found out that only GroupWare and SCM significantly affect firm productivity, while the

others have insignificant or even negative effects on productivity. Hendricks et al. (2007) also examined the effects of three major enterprise applications such as ERP, SCM, and CRM on firms' financial performance in stock returns and profitability. They found out that ERP and SCM positively influence firm performance, while CRM has no significant impact on firm performance. Table 1 summarizes prior research on the overall relationship between IT capability and firm performance.

Study	Methodology	Sample	Measure of IT capability	Finding
Bharadwaj (2000)	Matched sample comparison (IT leaders versus control company-similar size and industry)	149 IT leader firms from *Information Week* in 1991-1994	Ranking in IT capability	Positive
Chae et al. (2014)	Matched sample comparison (IT leaders versus control company-similar size and industry)	296 IT leaders with comparable companies from *Information Week 500* in 2000s	Ranking in IT capability	Negative
Hendricks et al. (2007)	Matched sample comparison	406 firms from *Business Wire, Dow Jones News Service, PR News-wire, and the Wall Street Journal* in 1991-1999.	Adoption of ES	Positive (ERP, SCM) / Negative (CRM)
Hitt et al. (2002)	Pooled Regression (adopters versus non-adopters)	5,603 firm implementing SAP during the 1986-1998.	Adoption of ERP	Positive
Santhanam & Hartono (2003)	Matched sample comparison (IT leaders versus industry average)	149 IT leader firms from *Information Week* in 1991-1994	Ranking in IT capability	Positive
Shin (2006)	Applied Cobb-Douglass production function	Survey data of 525 SMEs in 2002 and KIS-VALUE firm data for control variables	Adoption of ES	Positive (Groupware, SCM) / Insignificant or negative (ERP, CRM, KM, EAI)

Table 1. Previous research on the relationship between IT capability and firm performance

3 HYPOTHESES DEVELOPMENT

Though there are some mixed results on the relationship between IT capability and firm performance, we start with the positive association between them. Firm performance can be improved by IT capability through increasing revenues or reducing cost (Porter 2001). Especially, IT increases firm capability to communicate within and outside organization. Among a wide range of ES, ERP are developed for improving firm performance by supporting business process, enhancing data quality, and shortening decision making (O'Leary 2000). ERP help firms reorganize each system in the organization with standardized functions. In addition, by adopting ERP, companies can reduce time to spend duplicated works among departments, which results in improvement of firm performance (Brakely 1999). Moreover, ERP can update data in real time, track the product, and automate financial transactions, while providing timely reports on firm performance to managers in a much convenient

way (Hendricks et al. 2007; Mabert et al. 2003). Hence, as an indicator of IT capability, we focus on the adoption of ERP by firms in this research.

Meanwhile, as measures of firm performance, following previous research, we consider four financial indicators in profit ratios such as return on sales (ROS), return on assets (ROA), operating income to sales (OIS), and operating income to assets (OIA) (Balakrishnan et al. 1996; Barber & Lyon 1996; Barua et al. 1995; Bharadwaj 2000; Chae et al. 2014; Hitt & Brynjolfsson 1996; Weill 1992). Therefore, we set up hypotheses as follows:

> ***H1 (2, 3, and 4).*** *The profit ratios (Return on sales (ROS), Return on assets (ROA), Operating income to sales (OIS), and Operating income to assets (OIA)) of ERP adopters are higher than those of non-adopters.*

4 METHODOLOGY

4.1 Data

For this research, we use the *Survey of Business Activities* which is annually released by Statistics Korea (www.kostat.go.kr). With an objective to provide comprehensive statistics of firm-level business activities, Korean government has conducted the survey and provided results on the Internet from 2006 to 2012 as of February, 2015. The survey started with Korean companies in all industries, which have over 300 million Korean won (around US$ 3 million) in capital and over 50 in the number of employees.

The survey items include diverse business activities by Korea companies such as strategic alliance, R&D investment, financial performance, and adoption of e-business systems. Especially, in terms of adoption of e-business systems, it reports companies which adopt various Enterprise Systems (ES) including Enterprise Resource Planning (ERP) systems, Customer Relationship Management (CRM) systems, Knowledge Management (KM) systems and Supply Chain Management (SCM) systems.

In an annual basis, the survey covers around 10,000 Korean companies. However, we construct the panel data with 6,575 companies which appear for 7 consecutive years. Also, among reported e-business systems, we focus on ERP systems and examine the impact of companies' ERP adoption on their performance. ERP systems are representative and mostly adopted ES in the sample with the adoption rate of 63.7%, followed by CRM (9.1%), SCM (6.8%) and KMS (4.9%) as of 2012. To secure enough samples and consider the widely used measure of IT capability, we put a focus on ERP adopters. In addition, among various survey items, we use the following key variables in Table 2.

Variable	Description
Sales	The total amount of sales in million Korean won
Assets	The total amount of assets in million Korean won
Return	The total income before taxes in million Korean won
Cost	The total amount of costs in million Korean won
Employees	The number of employees in regular positions
Industry	The industry classification of the companies (e.g., primary, manufacturing, and service industry)
ROS	Return on sales (=Return/Sales)
ROA	Return on assets (=Return/Assets)
OIS	Operating income to sales (=(Sales-Cost)/Sales)
OIA	Operating income to assets (=(Sales-Cost)/Assets)

Table 2. Summary of key variables

In this research, to examine the effect of ERP adoption, we start with companies which adopt ERP systems in 2009. Dividing seven years into three periods such as pre-adoption period (from 2006 to 2008), adoption and implementation period (in 2009), and post-adoption period (from 2010 to 2012), we attempt to compare financial performance of ERP adopters and non-adopters in three-year average between pre-adoption period and post-adoption period. To smooth out fluctuations in periods, we average performance measures including ROA, ROS, OIA, and OIS, and other control variables such as the number of employees, the amount of sales and the amount of assets. The descriptive statistics of ERP adopters and non-adopters between pre-adoption period and post-adoption period is tabulated in Table 3.

Variable	Period	ERP adopters			Non-adopters		
		N	Mean	Std.Dev.	N	Mean	Std.Dev.
Sales	2006~2008	292	153048.3	519156.5	292	143545.0	405619.1
	2010~2012	292	228407.8	776066.4	292	203380.2	615280.0
Assets	2006~2008	292	153734.4	615541.9	292	149279.2	505761.6
	2010~2012	292	219604.8	813485.9	292	207149.6	682673.1
Return	2006~2008	292	9128.1	40243.2	292	7656.6	44644.0
	2010~2012	292	8012.2	50414.2	292	11619.1	51870.0
Cost	2006~2008	292	144883.4	492418.1	292	135597.4	387828.9
	2010~2012	292	218332.5	751288.3	292	192435.1	581297.4
Employees	2006~2008	292	264.9	414.1	292	269.2	460.8
	2010~2012	292	292.1	455.4	292	300.4	543.5
ROS	2006~2008	292	0.0460798	0.0988795	292	0.0580121	0.2804434
	2010~2012	292	0.0335558	0.1708722	292	0.0399017	0.1716502
ROA	2006~2008	292	0.0570913	0.0897454	292	0.0626475	0.1019977
	2010~2012	292	0.0443603	0.0991513	292	0.0478881	0.1120592
OIS	2006~2008	292	0.0482164	0.0777099	292	0.0502527	0.0845211
	2010~2012	292	0.0396388	0.0936414	292	0.0450077	0.0938629
OIA	2006~2008	292	0.0577008	0.0784257	292	0.0625261	0.0848584
	2010~2012	292	0.0483251	0.0747567	292	0.0473711	0.0867906

Table 3. Descriptive statistics of ERP-adopters versus non-adopters

4.2 Analysis Model

Most of prior research on this topic used the methodology of the matched sample comparison (Bharadwaj 2000; Chae et al. 2014; Santhanam & Hartono 2003). In that method, those studies examined the effect of IT capabilities on firm performance, comparing financial performance between IT leader companies and control companies which have similar characteristics of IT leaders. Following previous research strategy, we make use of propensity score matching (PSM) to effectively match ERP adopters with non-adopters. Then, combining it with difference-in-difference analysis (DID), we compare the difference in pre- and post-adoption of enterprise applications between the treatment group (i.e., ERP adopters) and the control group (i.e., non-adopters). Basically, PSM is not significantly different from ordinary least square (OLS) estimation with control variables and has limitation to control the problem of endogeneity. However, combining DID analysis with PSM, we can deal with the issue of endogeneity. In addition, different from the matched sample comparison in cross-sectional analysis, DID analysis can effectively capture the effects in time intervals.

According to research procedure in PSM with DID (Guo & Fraser 2014), we conduct our research in the following steps. At first, we calculate propensity scores for the companies, making use of criteria such as industry, sales, assets and employees, which were referred in previous research (Chae et al. 2014). For the dependent variable, we use a binary variable with 1 (i.e., ERP adoption) and 0 (i.e.,

non-adoption). For the independent variables, we take log-transformation with the amount of sales (*ln(Sales)*), the amount of assets (*ln(Assets)*), and the number of employees (*ln(Employees)*). Also, we consider two dummy variables for manufacturing industry (*IndDum1*) and service industry (*IndDum2*). Though this study uses the estimation results with a logistic model, a probit model also indicates the similar estimation results as Table 4.

Variable	*DV(ERP adoption)*			
	Logit regression		Probit regression	
	Parameter	Std.Err.	Parameter	Std.Err.
IndDum1	12.546	517.461	3.967	177.702
IndDum2	12.163	517.461	3.769	177.702
ln(Sales)	0.280***	0.103	0.152***	0.054
ln(Employees)	-0.159*	0.093	-0.082*	0.050
ln(Assets)	0.213**	0.086	0.113**	0.045
Constant	-18.849	517.461	-7.462	177.703
Log likelihood	-890.97041		-889.4254	

Table 4. Logit regression and probit regression results for propensity scores

Note: *** p<0.01, ** p<0.05, * p<0.1

Next, based on propensity scores above, we match the treatment group and the control group with 1:1 nearest neighbour matching algorithm. As a result, we obtain 292 ERP adopters and comparable 292 non-adopters in the sample. As shown in Figure 1, we check the substantial overlap in the characteristics of the companies which adopt ERP systems and do not. Along with the evidence in the existence of common support by visual analysis, we further check the quality of PSM, comparing the balance between the treatment group and the control group. As Table 5 presents, there is no significant difference in covariates between two groups.

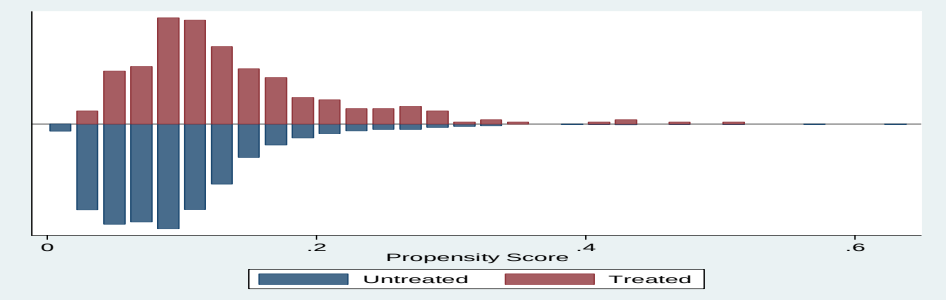

Figure 1. Common support between two groups

	Mean			t-test	
Variable	Treated	Control	%bias	t	p > |t|
IndDum1	.59589	.58904	1.4	0.17	0.867
IndDum2	.40411	.41096	-1.4	-0.17	0.867
ln(Sales)	10.797	10.774	1.8	0.21	0.835
ln(Employees)	5.1202	5.0579	7.3	0.84	0.400
ln(Assets)	10.682	10.689	-0.5	-0.06	0.953

Table 5. Difference of covariates between two groups

For the matched pair, firm performance between the treatment group and the control group in pre- and post-adoption period is modelled as Equation (1). In the equation, *i* indicates a matched pair of companies, *j* indicates a treatment (or a control) group, and *t* indicates the time period. $Performance_{ijt}$ addresses firm performance which is measured by ROA, ROS, OIA, and OIS. $Treat_{ij}$ is the dummy variable which is 1 if the company is in the treatment group and 0 if the company is in the control group. $Time_{ijt}$ is the dummy variable which has 1 if the period is in the post-adoption of ERP and 0 if the period is in the pre-adoption of ERP. In this study, β_3 is the focal parameter which captures the change of firm performance between ERP adopters in post-period and non-adopters in pre-period.

$$Performance_{ijt} = \beta_{0j} + \beta_1 * Treat_{ij} + \beta_2 * Time_{ijt} + \beta_3 * (Treat_{ij} \times Time_{ijt}) + \varepsilon_{it} \quad (1)$$

5 ANALYSIS RESULTS AND CONCLUSION

Based on the matched sample, we conduct the DID analysis and Table 6 shows the results. However, contrary to our hypotheses, it shows that ERP adoption does not make any significant difference in firm performance which is denoted in profit ratios. In column (1), with the dependent variable, ROS, it presents that there is no significant and positive impact from ERP adoption. Likewise, from column (2) and column (4), ROA, OIS, and OIA are not significantly and positively related with ERP adoption. Therefore, we can reject all of the hypotheses 1 to 4. In addition, to consider the impact of financial crisis in 2008, we test this model with different time periods in pre- and post-adoption and find out that analysis results are similar.

	(1) DV(ROS)	(2) DV(ROA)	(3) DV(OIS)	(4) DV(OIA)
Variables	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
$Treat_{ij}$	-0.012 (0.016)	-0.006 (0.008)	-0.002 (0.007)	-0.005 (0.007)
$Time_{ijt}$	-0.018 (0.016)	-0.015* (0.008)	-0.005 (0.007)	-0.015** (0.007)
$Treat_{ij} \times Time_{ijt}$	**0.006 (0.022)**	**0.002 (0.012)**	**-0.003 (0.010)**	**0.006 (0.010)**
Constant	0.058*** (0.011)	0.063*** (0.006)	0.050*** (0.005)	0.063*** (0.005)
N	1168	1168	1168	1168
R^2	0.0022	0.0051	0.0021	0.0061

Table 6. Analysis results

Note: *** p<0.01, ** p<0.05, * p<0.1

In this research, we re-investigate the relationship between IT capability and firm performance. With the sample of Korean companies which have adopted ERP in 2000s, we apply propensity score matching to effectively match ERP adopters with non-adopters. Then, combining it with difference-in-difference analysis, we compare the difference of firm performance between ERP adopters and non-adopters in time intervals. Contrary to our conventional knowledge, analysis results show that adoption of ERP makes no significant difference in firm performance which is measured by various profit ratios such as ROS, ROA, OIS and OIA.

Recent study argued that standardized and homogeneous information systems do not make any strategic advantages in 2000s (Chae et al. 2014). They argued that companies in the market follow the same practices by others (Chae et al. 2014). In line with the study, this research gives a practical implication in that mere ERP adoption can't help firms make strategic advantages against competitors.

In addition, extending the previous cross-sectional analysis with the matched sample comparison, this study methodologically tries to capture the effects between time intervals by applying PSM in combination with DID analysis. Also, though previous study makes use of a proxy measure in IT capability with rankings by IT magazine, for example, *Information Week*, this research utilizes much objective survey results by Korean government and reconfirms the relationship between IT capability and firm performance.

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