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Revisiting the Relationship between Information Technology Capability and Firm Performance: Focusing on the Impact of the Adoption of Enterprise Resource Planning Systems

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〈Content〉

Ⅰ. Introduction

Many information systems (IS) researchers have attempted to examine the relationship between information technology (IT) capability and firm performance. To explain the IT capabilities of firms, prior researchers have addressed 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 and Tanis, 2000). ES can include "ERP software and such related packages as advanced planning and scheduling, sales force automation, customer relationship management, and product configuration" (Markus and Tanis, 2000).

As sources of firms' competitive advantage,

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previous researchers focused on organizational resources and capabilities. Ascribing firms' superior performance to resources and capabilities is often referred to as the resource-based view (RBV) of the firm (Bharadwaj, 2000; Santhanam and Hartono, 2003). Defining resources, Wade and Hulland (2004) considered them both assets and capabilities that are available to firms. Extending the RBV perspective to IT-related resources, Bharadwaj (2000) categorized IT-based resources into IT infrastructure, human IT resources, and IT-enabled intangibles. The study addressed that firms can differentiate themselves and acquire unique organizational capabilities by combining IT-based resources (Bharadwaj, 2000).

The relationship between IT capability and firm performance is an on-going topic in IS research. Some researchers have argued that there is a positive relationship between IT capability and firm performance (Bharadwaj, 2000; Hitt et al., 2002; Santhanam and Hartono, 2003), whereas other researchers have revealed that there is no significantly positive relationship between IT capability and firm performance (Chae et al., 2014; Hendricks et al., 2007; Shin, 2006). Referring to a new trend in the adoption of enterprise applications, Shin (2006) noted that companies purchase off-the-self enterprise application software and do not develop their information systems in-house. Examining the fashion phenomenon in IT, Wang (2010) argued that although ERP systems were widely adopted across many industries during the 1990s, the systems were eventually institutionalized. As companies adopted standardized ES in the 2000s, a recent study argued that firms face challenges in differentiating advantages from their competitors with ES (Chae et al., 2014). Interestingly, according to a survey by CIO magazine, only 4% of IT leaders said their ERP systems provided their companies differentiation or a competitive edge (Wailgum, 2008).

Previous research on this topic has been limited in terms of samples and analysis method. Regarding the effect of IT capability on firm performance, whereas some research focused on the 1990s or early 2000s, other studies failed to adequately compare the impact of ERP adoption on firm performance between the treatment group and the control group. For example, as ERP emerged as an IT trend during the 1990s, many related studies focused on firms that adopted ERP in the 1990s and early 2000s (Hendricks et al., 2007; Hitt et al., 2002; Lim and Lee, 2007; Poston and Grabski, 2001; Shin, 2006). Additionally, previous studies failed to systematically compare the effect of ERP adoption between the treatment group and the control group (Hong et al., 2009; Sung et al., 2011) or ignored the considerable installation period required for ERP implementation (Hitt et al., 2002).

We reinvestigate the relationship between IT capability and firm performance with a recent sample and appropriate research methodology. The objective of this paper is to reexamine whether IT capability significantly and positively influences firm performance today. Specifically, using a sample of companies that have adopted ERP systems, we investigate whether the adoption of the enterprise application substantially contributes to the enhancement of firm performance between the pre- and post-adoption period.

From a methodological perspective, this study applies propensity score matching (PSM) in combination with difference-in-difference (DID) analysis. Examining the impact of IT capability on firm performance, previous studies have used the matched sample comparison, measuring the financial performance between IT leader companies and comparable control companies (Bharadwaj, 2000; Chae et al., 2014; Santhanam and Hartono, 2003). Combining DID analysis with PSM, we address the issue of endogeneity from self-selection. Additionally, in contrast to the matched sample comparison in cross-sectional analysis, DID analysis can effectively capture the effects in time intervals.

The remainder of the paper is structured as follows. In Section 2, we provide a literature review on IT capability and firm performance. Section 3 addresses the hypotheses development, and Section 4 presents research methodology with descriptive statistics of the sample data and analysis model. Section 5 provides the empirical analysis results. Finally, Section 6 discusses the implications and conclusions of this study.

Ⅱ. Literature Review

2.1 Resource-based View of the Firm

Analyzing the source of firms' competitive advantages, previous researchers considered organizational resources and capabilities. Barney (1991) argued that firms can gain competitive advantage and compete by leveraging their unique resources that are valuable, rare, imperfectly imitable, and non-substitutable. Attributing firms' superior performance to resources and capabilities, this is acknowledged as the RBV of the firm (Bharadwaj, 2000; Santhanam and Hartono, 2003). Wade and Hulland (2004) found that competitive advantages from resources can be sustained for a longer period, if the firm can prevent resource imitation or substitution from competitors' threats. While proponents of RBV defined resources as encompassing assets, knowledge, capabilities, and organizational processes, researchers distinguished between resources and capabilities (Bharadwaj, 2000; Grant, 1991)

Adopting the RBV approach for strategic

management, Grant (1991) suggested a framework for strategy formulation arguing that resources and capabilities are the foundations of the firm's strategy and the primary sources of the firm's profitability. Distinguishing resources with capabilities, he argued that "resources are the source of a firm's capability, whereas capabilities are the main source of its competitive advantage," which implies that firms' competitive advantage depends on organizational capability in assembling resources (Grant, 1991). Capabilities indicate an organization's ability to assemble, integrate, and deploy resources (Amit and Schoemaker, 1993; Russo and Fouts, 1997). By leveraging dynamic capability theory, Teece (1997) emphasized the importance of capabilities rather than piecemeal assets.

According to Grant's classification, resources are categorized into tangible, intangible, and personnel-based resources. Tangible resources include financial capital and physical assets, whereas intangible assets include assets such as reputation, brand image, and product quality. Personnel-based resources include technical expertise and other knowledge assets. Adopting Grant's classification of resources and extending RBV to IT-related resources, Bharadwaj (2000) categorized IT-based resources into (1) tangible resources comprising physical IT infrastructure components, (2) human IT resources comprising technical and managerial IT skills, and (3) intangible IT resources such as knowledge assets and synergy. Bharadwaj (2000) argued that firms can differentiate themselves and acquire unique organizational capabilities, combining IT-based resources.

Acknowledging a challenge in defining a firm's resources, Wade and Hulland (2004) considered resources as "assets and capabilities that are available and useful in detecting and responding to market opportunities or threats." Reviewing previous research on IS resources, Wade and Hulland (2004) argued that IS resources can be divided into two categories such as technology-based IS assets and systems-based IS capabilities. In their definition, the set of resources is composed of assets and capabilities, which are available to firms. However, researchers considered IS assets as the most vulnerable sources of sustainable competitive advantage to firms, because they can be easily copied by competitors (Teece et al., 1997; Wade and Hulland, 2004). Therefore, a firm's successful deployment of IS capabilities often determines competitive advantage (Christensen and Overdorf, 2000; Wade and Hulland, 2004).

2.2 IT Capability and Firm Performance

Although many IS researchers have investigated the association between IT

capability and firm performance, there is no consensus. Some researchers have emphasized the positive impacts of IT capability on firm performance (Bharadwaj, 2000; Hitt et al., 2002; Santhanam and Hartono, 2003), while other researchers have noted an insignificant or mixed relationship between IT capability and firm performance (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 positively influences firm performance. Extending the matched sample comparison method of Bharadwaj (2000), Santhanam and Hartono (2003) considered the average performance of all firms in the industry as a control group and reconfirmed the positive relationship. Focusing on IT capability in terms of ERP adoption, researchers revealed that ERP adopters show higher performance in various measures than non-adopters (Hitt et al., 2002; Lim and Lee, 2007).

However, not all researchers agree with a 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 the 1990s, standardized ES in the 2000s do not provide strategic advantages for ES adopters. Additionally, several studies found mixed results on the relationship between IT capability and firm performance. Examining 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 GW and SCM significantly affect firm productivity, whereas the others have insignificant or even negative effects on productivity. Hendricks et al. (2007) examined the effects of three major enterprise applications such as ERP, SCM, and CRM on firms' financial performance in stock returns and profitability. The authors found 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.

Table 1. Previous research on IT capability and firm performance

Study	Methodology	Sample	Measure of IT capability	Findings
Bharadwaj (2000)	Matched sample comparison (IT leaders versus control company-similar size and industry)	149 IT leaders from Information Week from 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 the 2000s	Ranking in IT capability	Insignificant
Hendricks et al. (2007)	Matched sample comparison	406 firms from Business Wire, Dow Jones News Service, PR News-wire, and the Wall Street Journal from 1991-1999.	Adoption of ES	Positive (ERP, SCM) / insignificant (CRM)
Hitt et al. (2002)	Pooled regression (ERP adopters versus non-adopters)	5,603 firms implementing SAP during the 1986-1998.	Adoption of ERP	Positive
Santhanam and Hartono (2003)	Matched sample comparison (IT leaders versus industry average)	149 IT leaders from Information Week from 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 (GW, SCM) /insignificant or even negative (ERP, CRM, KM, EAI)
Lim and Lee (2007)	Matched sample comparison (ERP adopters versus non-adopters)	Survey data of 80 firms from 1998-2002 and KIS-FAS financial information	Adoption of ERP	Positive

Ⅲ. Hypotheses Development

Although there are mixed results on the relationship between IT capability and firm performance, we first address the positive association. Firm performance can be improved by IT capability through increasing revenues or reducing costs (Porter, 2001). Particularly, IT increases a firm's capability to communicate within and outside the organization. From an RBV perspective, Bharadwaj (2000) argued that firm-specific IT resources such as IT infrastructure, human IT resources, and IT-enabled intangibles create firm-wide IT capability. The author also noted that if firms are successful in creating superior IT capability, they can enjoy superior financial performance (Bharadwaj, 2000).

Among a wide range of ES, ERP is developed to improve firm performance by supporting business processes, enhancing data quality and shortening the time for decision making (O'Leary, 2000). As packaged business software systems, ERP systems assist firms with standardized functions. By adopting ERP, companies can reduce time spent duplicated work among departments, which results in improved firm performance (Brakeley, 1999). Moreover, ERP can update data in real time, track products, and automate financial transactions while providing convenient and timely reports on firm performance to managers (Hendricks et al., 2007; Mabert et al., 2003).

With a sample of Korean companies, there have been attempts to investigate the impact of ERP adoption on firm performance, though most studies confirmed a significant positive impact. Focusing on small and medium-sized manufacturing companies, Hong et al. (2009) examined the effect of ERP implementation from a Balanced Score Card (BSC) perspective. Based on a survey of 96 companies, the authors found a positive relationship between ERP implementation and organizational performance (Hong et al., 2009). With a sample of 80 ERP adopters and comparable non-adopters for the period 1998 to 2002, Lim and Lee (2007) found that ERP enhances overall business functions including selling, marketing, purchasing, warehousing, accounting, and human resources, thereby contributing to profitability. Therefore, based on previous research, we set up the following hypotheses:

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.

Ⅳ. Methodology

4.1 Data

For the sample, we use the Survey of Business Activities released annually by Statistics Korea (www.kostat.go.kr). To provide comprehensive statistics of firm-level business activities, the Korean government has conducted a survey and provided results on the Internet from the year 2006 to the year 2013 as of December 2015. The survey began with Korean companies in all industries with over 300 million Korean won (around US$ 3 million) in capital and over 50 employees.

The survey items include diverse business activities by Korean companies such as strategic alliance, R&D investment, financial performance, and the adoption of e-business systems. Particularly, in terms of e-business system adoption, the survey reports on

companies that adopt various ES including ERP, CRM, KM, and SCM systems.

The survey covers approximately 10,000 Korean companies on an annual basis. We construct the panel data with companies that reported their business activities for consecutive years. Additionally, 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 most adopted ES in the sample with an adoption rate of 63.7%, followed by CRM (9.1%), SCM (6.8%) and KMS (4.9%) as of 2012. Among various survey items, we use the key variables listed in Table 2 for this research.

IT capability encompasses various types such as IT infrastructure, human IT resources and IT-enabled intangibles (Bharadwaj, 2000). Researchers focused on IT capability of firms, considering the adoption of ERP as representative of ES (Hendricks et al., 2007; Hitt et al., 2002; Lim and Lee, 2007; Shin, 2006) or the rankings released by Information Week (Bharadwaj, 2000; Chae et al., 2014; Santhanam and Hartono, 2003). As measures of firm performance, previous research used 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 and Lyon, 1996; Barua et al., 1995; Bharadwaj, 2000; Chae et al., 2014; Hitt and Brynjolfsson, 1996; Weill, 1992). In summary, following previous research, this study considers the constructs and measurement in Table 3.

Table 2. Previous research on the relationship between IT capability and firm performance

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 3. Summary of constructs and measurement

Category	Constructs	Definition	Measurement	Sources
Dependent variables	IT capability	A firm's ability to employ IT resources	ERP adoption	Hendricks et al. (2007); Hitt et al. (2002); Lim and Lee (2007); Shin (2006)
Independent variables	Superior business performance	A firm's higher profit than the other control firm	Return on sales (ROS), return on assets (ROA), operating income to sales (OIS), operating income to assets (OIA)	Balakrishnan et al. (1996); Barber and Lyon (1996); Barua et al. (1995); Bharadwaj (2000); Chae et al. (2014); Hitt and Brynjolfsson (1996); Weill (1992)

4.2 Analysis Model

Most prior research on this topic used the methodology of matched sample comparison (Bharadwaj, 2000; Chae et al., 2014; Santhanam and Hartono, 2003). For this method, the studies examined the effect of IT capabilities on firm performance, comparing financial performance between IT leader companies and control companies with similar characteristics of IT leaders. In previous research, assessing the relationship between IT capability and firm performance depended on how the control sample was carefully matched to the treatment sample. However, there was much room for errors in matching pairs of firms which were drawn manually. In addition, there could be endogeneity issues from self-selection. For example, IT leader companies are more likely to have interests in acquiring superior IT capabilities.

To address this issue, we make use of sequential applications of propensity score matching (PSM) and difference-in-difference (DID) analysis. At first, PSM is utilized to substantially enhance the similarity between the treatment group (i.e., ERP adopters) and the control group (i.e., non-adopters). The fundamental feature of PSM is that it balances data through matching the treatment group and the control group on probabilities of treatment, which are denoted in propensity scores (Guo and Fraser, 2014, p.35). If a pair of treatment and control parties have a similar propensity score, they are considered as comparable (Guo and Fraser, 2014, p.130).

Subsequently, we employ DID analysis on the resulting matched sample through PSM. It compares the difference in pre- and post-adoption differences between ERP adopters and non-adopters. Simply, the difference in pre- and post-adoption of ERP adopters may not presents accurate impact from ERP adoption, owing to probable extraneous factors between pre- and post-adoption periods. Therefore, we need to

use reference companies that do not adopt ERP.

In summary, this research uses PSM to effectively match ERP adopters with non-adopters. Then, combining PSM with DID analysis, we compare the differences in pre- and post-adoption of ERP between the treatment group (i.e., ERP adopters) and the control group (i.e., non-adopters). In previous IS research, some researchers employed PSM in combination with DID analysis for this quasi-experimental research design. Examining the effect of customers' social media participation on the frequency of customer visits and profitability, Rishika et al. (2013) used this approach to particularly address customer self-selection issue that may come from customer specific unobserved factors in customers' social media participation. Evaluating effectiveness of Korean government's supporting program on clean workplace, Kim (2013) applied sequential applications of PSM and DID to eliminate self-selection bias and thus better evaluate effectiveness of the program.

Basically, PSM is not significantly different from ordinary least square (OLS) estimation with control variables and has limitations in controlling the problem of endogeneity from self-selection. For example, firms that show good financial performance are likely to adopt ERP. However, combining DID analysis with PSM, we can address the issue of endogeneity. In contrast to the matched sample comparison in cross-sectional analysis, PSM in combination with DID analysis allows us to compare the differences in pre- and post-adoption of ERP between the treatment group and the control group. From a methodological perspective, researchers showed that it can significantly reduce the possible biases from observable and unobservable variables and contribute to the consistency in estimates (Rishika et al., 2013; Kim, 2013).

Following the research procedure of PSM with DID (Guo and Fraser, 2014), we first calculate propensity scores for the companies, using criteria such as industry, sales, assets, and employees, which were referred to in previous research (Chae et al., 2014). Next, based on the estimated propensity scores, we match the treatment group and the control group. Among many matching algorithms, we make use of the 1:1 nearest neighbour matching algorithm. Then, we check the substantial overlap in the characteristics of the companies that adopt ERP systems and those that do not. Using the evidence of 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. Finally, for the matched pair, we apply a DID analysis model shown in Equation (1) to compare firm performance between the treatment group and the control

group for the pre- and post-adoption periods.

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

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 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 that captures the differences in firm performance between ERP adopters and non-adopters between the pre- and post-periods. The difference-in-difference parameter can be shown as Table 4.

Table 4. Difference-in-difference parameter

	Pre-adoption	Post-adoption	Difference
Non-adopters	β_0	$\beta_0+\beta_2$	β_2
ERP-adopters	$\beta_0+\beta_1$	$\beta_0+\beta_1+\beta_2+\beta_3$	$\beta_2+\beta_3$
Difference	β_1	$\beta_1+\beta_3$	β_3

Researchers argued that there is a time lag in gaining benefits from IT investments (Brynjolfsson and Hitt, 1998). Examining the impact of ES adoption, previous research acknowledged that a considerable period for ERP installation is required for approximately one or two years (Hendricks et al., 2007; O'Leary, 2000). Therefore, we attempt to examine the effect of ERP adoption in a longitudinal study, dividing companies' activities into three periods: the pre-adoption period, the adoption/installation period, and the post-adoption period. To ensure consistency in the analysis results, we test our model in varying analysis periods in three scenarios, as in Table 5.

Table 5. Summary of analysis scenarios

Scenario	Pre-adoption period	Adoption and installation period	Post-adoption period
1	2006~2008 (3 years)	2009 (1 year)	2010~2012 (3 years)
2	2006~2007 (2 years)	2008~2009 (2 years)	2010~2012 (3 years)
3	2006~2008 (3 years)	2009~2010 (2 years)	2011~2013 (3 years)

4.3 Analysis Results

We start with companies that adopted ERP systems in 2009. In our first scenario, dividing seven years into three periods: the pre-adoption period (from 2006 to 2008), the adoption and installation period (in 2009), and the post-adoption period (from 2010 to 2012), we attempt to compare financial performance of ERP adopters and non-adopters fir a three-year average between the pre-adoption period and the post-adoption period. Considering the installation period in 2009, we obtain conservative estimation results for the overall performance of ERP adopters controlling for the global financial crisis in that year.

To smooth out periodic fluctuations, 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 the pre-adoption period and the post-adoption period is tabulated in Table 6. In terms of sales, assets, and employees in average, both ERP-adopters and non-adopters show increasing trends in volume and size. However, overall return and profit ratios show a decreasing trend.

Table 6. Descriptive statistics of ERP-adopters versus non-adopters

Variable	Period	ERP-adopters			Non-adopters		
		N	Mean	Std.Dev.	N	Mean	Std.Dev.
Sales	2006~2008	264	165487.4	544507.8	264	340640.5	2207597
	2010~2012	264	247411.3	813881.4	264	480481.6	3151109
Assets	2006~2008	264	166112.2	646030.8	264	326046.4	2151190
	2010~2012	264	236904.6	853569.3	264	515870.2	3584871
Return	2006~2008	264	9908.072	42247.86	264	16795.81	135612.9
	2010~2012	264	8717.095	52971.81	264	45746.29	420012.4
Cost	2006~2008	264	156715.4	516465.3	264	325029.3	2108980
	2010~2012	264	236459.9	787960.8	264	447064	2874633
Employees	2006~2008	264	277.3586	432.4409	264	595.8472	3795.442
	2010~2012	264	306.5694	475.3211	264	631.8573	4136.173
ROS	2006~2008	264	.0467707	.1017671	264	.0505278	.1382632
	2010~2012	264	.0325688	.1773595	264	.0341658	.1724958
ROA	2006~2008	264	.0592917	.089459	264	.058032	.0857311
	2010~2012	264	.0440248	.1017737	264	.0436291	.1150105
OIS	2006~2008	264	.048366	.0777749	264	.0476625	.1030771
	2010~2012	264	.0400771	.0964421	264	.0471686	.079698
OIA	2006~2008	264	.0595385	.0740112	264	.0554359	.1311981
	2010~2012	264	.0487859	.0748473	264	.0446835	.1465209

Table 7. Logit regression and probit regression results for propensity scores

Variable	DV(ERP adoption)			
	Logit regression		Probit regression	
	Parameter	Std.Err.	Parameter	Std.Err.
IndDum1	12.996	568.796	4.028	129.506
IndDum2	12.491	568.796	3.764	129.506
ln(Sales)	0.313***	0.110	0.174***	0.060
ln(Employees)	-0.153	0.103	-0.082	0.055
ln(Assets)	0.303***	0.093	0.166***	0.050
Constant	-20.293	568.796	-8.138	129.507
N	2,245		2,245	
Log likelihood	-729.90373		-727.55987	

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

According to the PSM with DID research procedure (Guo and Fraser, 2014), we calculate propensity scores for the companies, using criteria such as industry, sales, assets and employees. 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 use the log-transformation with the sales amount (ln(Sales)), the amount of assets (ln(Assets)), and the number of employees (ln(Employees)). Additionally, we consider two dummy variables for the manufacturing industry (IndDum1) and the service industry (IndDum2). Although this study uses the estimation results with a logistic model, a probit model also indicates similar estimation results, which are shown in Table 7.

Based on the estimated propensity scores, we match the treatment group and the control group applying the 1:1 nearest neighbour matching algorithm. To refine our sample, we confirm the control group that did not adopt ERP from the year 2006 to the year 2012. Then we select the treatment group that reported adopting ERP in 2009 and used it thereafter. As a result, we obtain 264 ERP adopters and comparable 264 non-adopters in the sample. Figure 1 shows verification of the substantial overlap in the characteristics of companies that adopt ERP systems and the companies that do not. In conjection with the evidence for the existence of common support by visual analysis, we check the quality of PSM comparing the balance between the treatment group and the control group. Table 8 shows no significant difference in the covariates between the two groups.

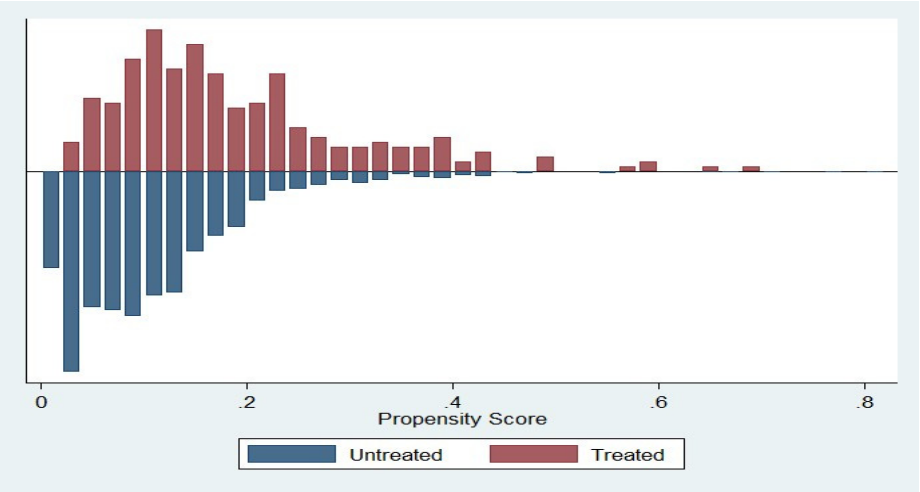

Figure 1. Common support between the two groups

Table 8. Difference of covariates between two groups

	Mean			t-test	
Variable	Treated	Control	%bias	t	p > |t|
IndDum1	.60227	.62121	-3.9	-0.45	0.656
IndDum2	.39773	.37879	3.9	0.45	0.656
ln(Sales)	10.855	10.824	2.4	0.25	0.802
ln(Employees)	5.1501	5.0763	8.6	0.89	0.376
ln(Assets)	10.753	10.765	-0.8	-0.09	0.929

Based on the matched sample, we conduct the DID analysis and Table 9 shows the results. In column (1), with the dependent variable, ROS, we find no significant impact from ERP adoption with our sample (estimated coefficient = 0.002; p-value > 0.1). Similarly, in terms of ROA shown in column (2), ERP adoption has no significant effect on firm performance (estimated coefficient = -0.001; p-value > 0.1). Columns (3) and (4) show that ERP adoption makes no significant difference in terms of both OIS (estimated coefficient = -0.008; p-value > 0.1) and OIA (estimated coefficient = -0.000; p-value > 0.1). Therefore, we reject all of the hypotheses 1 to 4. Contrary to our hypotheses, analysis results show that ERP adoption does not make any significant difference in firm performance which is denoted in profit ratios such as ROS, ROA, OIS, and OIA.

Table 9. Analysis results in the first scenario

	(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.)
$Treat_{ij}$	-0.004 (0.013)	0.001 (0.009)	0.001 (0.008)	0.004 (0.010)
$Time_{ijt}$	-0.016 (0.013)	-0.014* (0.009)	-0.000 (0.008)	-0.011 (0.010)
$\boldsymbol{Treat_{ij} \times Time_{ijt}}$	0.002 (0.019)	-0.001 (0.012)	-0.008 (0.011)	-0.000 (0.014)
Constant	0.051*** (0.009)	0.058*** (0.006)	0.048*** (0.006)	0.055*** (0.007)
N	1,056	1,056	1,056	1,056
R2	0.0027	0.0057	0.0014	0.0027

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

In the second analysis, we consider different intervals such as the pre-adoption period (from 2006 to 2007), the adoption and installation period (from 2008 to 2009), and the post-adoption period (from 2010 to 2012). We follow the same research procedure. First, based on the estimated propensity scores, we match 266 ERP adopters and comparable 266 non-adopters with the same matching algorithm. Then, after checking the substantial overlap in the characteristics of ERP adopters and non-adopters and the visual evidence of the existence of common support, we ensure the quality of PSM comparing the balance between the treatment group and the control group. Again, we confirm that there is no significant difference in covariates between the two groups. For the matched pair, we apply Equation (1) and estimate β3 which is the parameter of $Treat_{ij} \times Time_{ijt}$.

Table 10 shows the analysis results with different intervals and confirms results that are consistent with our previous results. In column (1), with the dependent variable ROS, we find that there is no significant impact of ERP adoption (estimated coefficient = 0.008; p-value > 0.1). In terms of ROA in column (2), we also find that ERP adoption makes no significant difference (estimated coefficient = 0.003; p-value > 0.1). Columns (3) and (4) show that the coefficients of $Treat_{ij} \times Time_{ijt}$ are not significantly and positively related with firm performance denoted in OIS and OIA.

Table 10. Analysis results in the second scenario

	(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.)
$Treat_{ij}$	-0.007 (0.011)	-0.004 (0.009)	-0.001 (0.008)	0.005 (0.010)
$Time_{ijt}$	-0.011 (0.011)	-0.015* (0.009)	-0.003 (0.008)	-0.013 (0.010)
$\boldsymbol{Treat_{ij} \times Time_{ijt}}$	0.008 (0.015)	0.003 (0.013)	0.008 (0.011)	0.008 (0.014)
Constant	0.051*** (0.008)	0.065*** (0.006)	0.043*** (0.006)	0.056*** (0.007)
N	1,064	1,064	1,064	1,064
R2	0.0013	0.0044	0.0009	0.0035

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

In the third analysis, we collect data for the year 2013, which were recently released by Statistics Korea in 2015, and apply the same analysis procedure. In this case, eight years in total are divided into three periods: the pre-adoption period (from 2006 to 2008), the adoption and installation period (from 2009 to 2010), and the post-adoption period (from 2011 to 2013). Considering the post-adoption period from 2011 to 2013, we expect the impact from the global financial crisis to be minimized. In this case, we match 249 ERP adopters and comparable 249 non-adopters using the estimated propensity scores with the same matching algorithm. Identifying the substantial overlap in the characteristics of ERP adopters and non-adopters and the visual evidence of the existence of common support, we confirm the quality of PSM. Again, we confirm that there is no significant difference in covariates between the two groups.

Table 11 shows results that are consistent with the previous results. In column (1), with the dependent variable ROS, there is no significant impact of ERP adoption (estimated coefficient = -0.008; p-value > 0.1). Additionally, in terms of ROA shown in column (2), ERP adoption makes no significant difference in firm performance (estimated coefficient = -0.006; p-value > 0.1). Furthermore, according to column (3) and column (4), the coefficients of $Treat_{ij} \times Time_{ijt}$ are not significantly and positively related with firm performance denoted in OIS and OIA. Therefore, we again reject all of the hypotheses 1 to 4.

Table 11. Analysis results in the third scenario

	(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.)
$Treat_{ij}$	-0.016 (0.013)	-0.005 (0.009)	-0.014 (0.008)	-0.007 (0.007)
$Time_{ijt}$	-0.021 (0.013)	-0.020** (0.009)	-0.015* (0.008)	-0.021*** (0.007)
$\boldsymbol{Treat_{ij} \times Time_{ijt}}$	-0.008 (0.019)	-0.006 (0.012)	-0.004 (0.012)	0.001 (0.010)
Constant	0.063*** (0.009)	0.064*** (0.006)	0.065*** (0.006)	0.070*** (0.005)
N	996	996	996	996
R2	0.0122	0.0158	0.0153	0.0201

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

Ⅴ. Discussion and Conclusion

This study reinvestigates the relationship between IT capability and firm performance. Replications and updates that contribute to the robustness of a theory are an important scientific effort (Chae et al., 2014; Santhanam and Hartono, 2003). Overcoming the restrictions of previous research in terms of research sample and analysis method, this study revisits an on-going topic. Specifically, extending previous analysis approaches with a sample of Korean companies that adopted ERP in the 2000s, we apply propensity score matching to effectively match ERP adopters with non-adopters. Then, combining this result with difference-in-difference analysis, we compare the differences in firm performance between ERP adopters and non-adopters in time intervals. Contrary to conventional knowledge, the analysis results show that ERP adoption produces no significant differences in firm performance which is measured by various profit ratios such as ROS, ROA, OIS, and OIA.

Revisiting the relationship between IT capability and firm performance, this research contributes in the following aspects. From a theoretical perspective, this research contributes by enhancing the understanding of the relationship between IT capability and firm performance. While some researchers have argued that there is a positive relationship between IT capability and firm performance (Bharadwaj, 2000; Hitt et al., 2002; Santhanam and Hartono, 2003), other researchers have argued that there is no significant positive

relationship (Chae et al., 2014; Hendricks et al., 2007; Shin, 2006). Revisiting the on-going research topic with recent samples from the 2000s and focusing on IT capability measured by ERP adoption, this study shows that simply adopting ERP has no significant positive impact on firm performance. These analysis results reconfirm that IT capability based on standardized and homogeneous information systems provides no competitive advantages to firms (Chae et al., 2014; Wang, 2010).

This research also provides practical insight to practitioners, suggesting that the adoption of commoditized information systems cannot guarantee competitive advantages to firms. Recent studies argued that standardized and homogeneous information systems do not provide any strategic advantages in the 2000s (Chae et al., 2014). The study argued that companies in the market tend to follow the same practices (Chae et al., 2014). Carr (2003) acknowledged that IT is fundamentally easy for other firms to copy. When commoditized, IT tends to lose its crucial features as a rare and inimitable resource, failing to serve as a competitive advantage (Carr, 2003). If all firms follow the same practices, there are no competitive advantages (Wang, 2010). Business practitioners should be aware that ERP adoption alone cannot help firms obtain strategic advantages against competitors, and such advantages require strategic management and use of IT resources.

From a methodological perspective, this study extends the previous cross-sectional analysis with the matched sample comparison applying PSM in combination with DID analysis. This approach addresses the issue of endogeneity. Additionally, it effectively captures the effects in time intervals. Although previous study uses a proxy measure for IT capability with IT magazine rankings, for example, Information Week, this research utilizes objective survey results from the Korean government. Measuring ERP adoption as IT capability, this research revisits the relationship between IT capability and firm performance.

However, this research has some limitations and implications for future research. First, this study measures IT capability with ERP adoption only. Although the Survey of Business Activities released by Statistics Korea included other ES such as CRM, KMS, and SCM, we have no choice but to focus on ERP, owing to sample limitations. If future research can analyze the impact of various ES, it would be helpful to improve the generalizability of the analysis results in this study. Second, this research is confined to the sample of Korean companies. In other different cultural environments, there may be differences in the deployment and use of ERP depending on regions. Therefore, future studies should investigate the impact of IT capability on firm performance with samples from various

regions. Third, this research calls for further studies on information management of IT capability. Mithas et al. (2011) argued that there is limited research empirically investigating the relationship between information management capability and firm performance.

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오세환 (Sehwan Oh)

현재 경북대학교 경영학부에서 조교수로 재직 중이다. 서울대학교 경제학부(학사)를 졸업했으며 美 카네기멜론대에서 e-Business 석사, 서울대학교에서 경영정보학 박사 학위를 받았다. International Journal of Mobile Communications, Journal of Electronic Commerce Research, ETRI Journal 등에 논문을 게재했으며 주요 연구 관심분야는 소셜미디어, 온라인구전, 전자상거래, 정보기술 역량 등이다.

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이새롬 (Saerom Lee)

현재 서울대학교에서 2010년부터 석박사 통합과정으로 경영정보학 박사학위를 수료하고 연구원으로 재직 중이다. 부산대학교 무역국제학(학사)을 전공하였다. Journal of Electronic Commerce Research, 전자거래학회지, 벤처창업연구 등에 논문을 게재하였다. 주요 연구 분야는 개방적 협업, 기술 혁신, 기술 예측, 그리고 온라인 구전 등이다.

<Abstract>

Revisiting the Relationship between Information Technology Capability and Firm Performance: Focusing on the Impact of the Adoption of Enterprise Resource Planning Systems

Sehwan Oh · Hyunmi Baek · Saerom Lee

Purpose

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 (ERP) systems by firms as a proxy measure for information technology capability, we reexamine whether the association is significantly positive.

Design/methodology/approach

Previous research on this topic had some limitations to the samples and analysis method. Some research focused only on the 1990s or early 2000s, and other studies failed to adequately compare the impact of ERP adoption on firm performance between the treatment group and the control group. In this research, extending previous analysis approaches with the matched sample comparison of IT leaders and the control group, we attempt to apply propensity score matching in combination with difference-in-difference analysis with a sample of Korean firms that adopted ERP systems in the late 2000s. We match ERP adopters and non-adopters with propensity score matching and compare their financial performance with difference-in-difference estimation between the pre- and post-adoption periods.

Findings

According to our analysis, we find no positive and significant relationship between ERP adoption and firm performance in profit ratios. This research shows that, contrary to the era of proprietary information systems, standardized information systems today have no additional competitive

advantages over competitors.

Keywords: Information technology capability, Firm performance, Enterprise Systems, Enterprise Resource Planning systems

<국문초록>

정보기술 역량과 기업 성과 간 관계 재고찰: 전사적자원관리(ERP) 시스템 도입 효과를 중심으로

오세환 · 백현미 · 이새롬

연구목적

기존 정보시스템 연구에서 정보기술 역량과 기업 성과 간 관계에 대해 다양한 관점의 많은 연구들이 있었음에도 불구하고 아직까지 공통된 결론에 이르지는 못하고 있다. 본 연구는 전사적자원관리(ERP) 시스템 도입을 중심으로 정보기술 역량을 파악하여 정보기술 역량과 기업 성과 간 관계에 대한 재고찰을 시도한다.

연구설계/방법론/접근법

기존 관련 연구들은 1990년대나 2000년대 초반의 다소 오래된 기업사례들을 대상으로 하거나 ERP를 도입한 처리그룹과 이에 상응하는 통제그룹을 적절히 매칭하지 못한 채 양자 간 관계를 분석하고 있다는 점에서 자료 및 분석 방법 측면의 문제점을 갖고 있다. 이에 따라 본 연구는 2000년대 후반 들어 전사적자원관리 시스템을 도입한 기업들을 중심으로 성향점수매칭(propensity score matching) 및 이중차이분석(difference-in-difference) 방법을 적용하여 전사적자원관리 시스템을 도입한 기업과 이에 상응하는 미도입 기업을 체계적으로 매칭하고 이들 간의 기간 간 성과 차이를 분석한다.

결과

본 연구 결과에 따르면 전사적자원관리 시스템 도입 기업과 미도입 기업 간 수익성 지표에서 통계적으로 유의한 차이는 없는 것으로 나타났다. 본 연구는 정보시스템의 전유가 경쟁력을 제공했던 과거와 달리 최근 표준화된 정보시스템의 등장과 더불어 단순히 정보시스템 도입 만으로는 더 이상 경쟁 우위를 달성할 수 없다는 점을 시사하고 있다.

키워드: 정보기술 역량, 기업 성과, 엔터프라이즈 시스템, 전사적자원관리 시스템

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