Longitudinal Effects of IT Investment on Organizational Performance

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Abstract

To reveal the evidence that IT productivity paradox does not exist in reality, we examine the relationship between IT investment and organizational performance under a time lag and the information intensity of industry. As a result, we not only found the positive effect of IT investment at an instant, but also positive lagged effect. Furthermore, both the immediate and lagged effect in a high information-intensive industry are larger than in a low one, and the size of lagged effect is larger than any immediate effect. Also, the effects of IT investment in a high information-intensive industry appear more quickly than in a low one.

Keywords:

Information Technology (IT) Investment; Time Lag; Information Intensity of Industry; IT Productivity Paradox

Introduction

Using Information Technology (IT) better may be the source for the competitive advantage of an organization. The more that executives become concerned about IT investment and its productivity, the more interested researchers become about their relationship. Although studies have been done on the effects of IT investment, there is little agreement on the relationship between IT investment and its productivity. We can classify researchers concerned about IT investment productivity into three groups. First, some researchers have asserted that there is no relationship between IT investment and organizational performance [1, 5, 27, 29, 31]. Rather, they say some IT investment has a negative effect on the productivity of an organization because of an inefficient allocation of resources. Elasticities of other management activities (e.g. marketing, Research & Development (R&D), advertising) and other capital on organizational performance are greater then the elasticity of IT capital [4, 18]. In the worst case, as firms invest more in IT, there is a greater need for coordination between different activities and systems across all functional areas of the organization [7].

The second group of researchers has asserted that there is a significant positive relationship in IT investment and organizational performance. If firms invest more in IT, their performances increase more [2, 3, 4, 19, 21, 28]. Though scholars describe some limitations in their studies, they can still explain the positive relationship between IT investment and organizational performance.

The third group of researchers has suggested ambiguous or mixed opinions in their research results. They report that in some performance variables there is a positive relationship between IT investment and organizational performance, while in other performance variables there is a negative one [6, 12, 18, 20, 26, 30, 32, 34]. They have tried to explain the possible reasons for such a perplexing result.

Why are different results suggested in the explanation of the same status quo? It is possible that there are variances in sample period, industry, level of analysis, and methodology. Moreover, we can think another reason. It is quite likely that they have not considered the critical factors in the framework of research about IT payoffs [5, 17, 27].

Jurison [17] suggests that the causes of inconsistent results are inappropriate measures, inappropriate units of analysis, failure to account for the time lag, and narrow perspective in measuring a firm's output. Also, Quinn and Baily [27] write that the reasons why increasing IT investment cannot be shown to have an effect on productivity are time lag and the inaccurate calculation of productivity. In addition, Brynjolfsson [5] says that the various explanations for the IT productivity paradox that have been proposed can be grouped into four categories: 1) Measurement error (outputs (and inputs) of information-using industries are not being properly measured by conventional approaches); 2) Lags (time lags in the payoffs to IT make analysis of current costs vs. current benefits misleading); 3) Redistribution (it is especially likely that IT is used in redistributive activities among firms, making it privately beneficial without adding to total output); 4) Mismanagement (the lack of explicit measures of the value of information makes it particularly vulnerable to misallocation and overconsumption by managers). Moreover, Devaraj and Kohli [8] describe that one of the factors contributing to the IT productivity paradox is a snapshot view without time lag. The true benefits that will be observed after an initial period might range anywhere from several days to several months, and in some cases even years, depending on the size and complexity of the IT implementation. Therefore, any evaluation of IT benefits must be cognizant of this lagged

aspect and assess benefits over time [8].

In this study, we are concerned with time lags that have been commonly pointed by many researchers in the relationship between IT investment and organizational performance. Also, this time lag is the subject that some researchers have written about as one of the limitations of their study, and a future area of research [22, 24, 28]. Because implementing IT project takes a long time in general, and the workers' learning of new information systems may be needed, the consideration of time lag is indispensable to fully see all effects of IT investment. After considering the time lag, the so-called "productivity paradox" of IT investment will disappear.

Moreover, the additional cause of empirically inconsistent results may be the lack of consideration for characteristics of each industry sector. In an organizational context, the role of IT should be a decisive factor influencing its performance. Depending on the role of IT in each industry, not only the relationship between the two variables but also the size of the effect from the IT investment may be different [21]. At the same time, not only the maximum size of the time lag in IT investment and its payoffs, but also the total shape of time lag can vary according to the information intensity of an industry (high information-intensive industry vs. others).

Not suggesting various causes and possible explanations for the IT productivity paradox, but finding clear empirical evidences about payoffs from IT investment can be a valuable area of study. Our research questions are below:

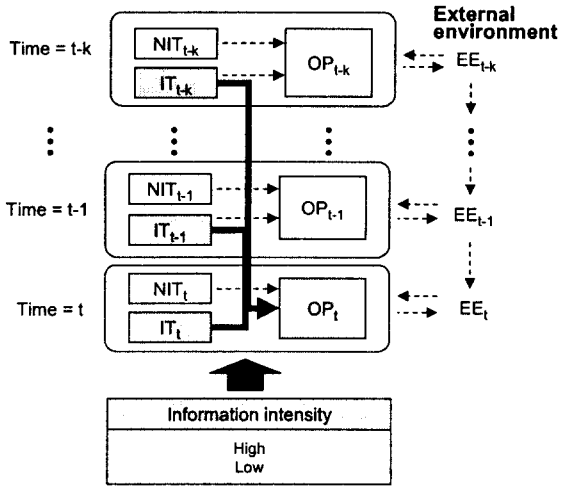
1) What is the relationship between IT investment and an organizational performance? Positive or no relationship. 2) What is the relationship taking into account time lag and the information intensity of industry? 3) Does the magnitude of any IT effect vary according to information intensity of an industry? 4) Do characteristics of the time lag have a connection with the information intensity of an industry? 5) What is the size of the time lag?

The organization of this paper is as follows. In section 2, we suggest a research model and framework for overcoming the IT productivity paradox. In section 3, we analyze the result of research. We offer our limitations and concluding remarks in section 4.

Methods

Research model

The research model with the time lag and the information intensity of industry appears in Figure 1. The organization at each period is affected by factors in the external environment. The organizational performance at specific period t (OP_t) is affected by not only the sum of the IT factor at period t, t-1, t-2, ..., t-k (IT_t, IT_{t-1}, ..., IT_{t-k}) but also non-IT factors at period t, t-1, t-2, ..., t-k (NIT_t, NIT_{t-1}, ..., NIT_{t-k}). In this study, we are concerned about the shading and coarse line in Figure 1. We will find the effect of IT investment on organizational performance with time lag. Furthermore, we use the information intensity of industry because the effect of IT investment may not be equivalent in all industries.



The k is lag, IT_t is IT factor at time t, NIT_t are other factors except IT at time t, OP_t is organizational performance at time t, and EE_t is external environment factor at time t

Figure 1 - Research Model

According to the classification of Stiroh [30], we classify his computer-using sectors and computer-producing sector as a high information-intensive industry. Printing and publishing (major group of SIC: 27), stone, clay and glass (32), non-electrical machinery (35), electrical machinery (36), instruments (38), trade (Division F and G of SIC), FIRE (Financial services, Insurance, Real Estate) (Division H), and other services sectors (Division I) are included in the industries of high information intensity. The remaining sectors are classified into industries of low information intensity.

The organizational performance at year t is influenced by IT investment at year t, IT investment at year t-1, ..., and IT investment at year t-k simultaneously. Our equation to consider the cumulative lagged effects of IT investment is below.

$$OP_t = \alpha + \beta_0 IT_t + \beta_1 IT_{t-1} + \ldots + \beta_k IT_{t-k} + \varepsilon_t \quad (1)$$

where the k is lag, an OP_t is organizational performance at year t, IT_t is IT investment at year t, α is the intercept, β_k is the partial coefficient of IT investment at year t-k that influences organizational performance at year t, and ε_t is the error term at year t.

In equation (1), we include successively the lagged effect of IT investment to examine the incremental variance explained by IT lagged effects. That is, we increase gradually the size of k by integer. We estimate the model with a separately run Weighted Least Squares (WLS) regression approach with error-components pooling procedure [23] for the total sample, a high information-intensive industry sample, and a low one because our data is panel data. Moreover, when the increase of the adjusted

R^2 stops or the sign of the IT investment coefficients changes, to decide the best fitting lagged model we stop adding the longer lagged effect variable in our model [13, 23].

To compare two regressions in a high information-intensive industry and a low one, we use the dummy variable approach below.

$$OP_t = a_1 + a_2 D + \sum_{i=0}^{k} \{b_i IT_{t-i} + c_i (D \cdot IT_{t-i})\} + u_t \quad (2)$$

where the k is lag, an OP_t is organizational performance at year t, IT_{t-i} is IT investment at year t-i, a_1 is the intercept, a_2 is the differential intercept, b_i is the partial coefficient of IT investment at year t-i that influences organizational performance at year t, c_i is the differential slope coefficient at year t-i, D=1 for observations in a high information-intensive industry and zero for observations in a low one, and u_t is the error term at year t.

We will examine the significance of a_2 in equation (2) to compare two intercepts in a high information-intensive industry and a low one. Also, to compare slopes of IT investment, we will analyze the significance of c_0 for the immediate effect of IT investment and c_k for k-year lagged effect of IT investment.

Data

Our sample is comprised of data from *Informationweek* magazine. *Informationweek* data is gathered from an annual survey and published in their annual special issue (*Informationweek* 500). Researchers were concerned about the effect of IT investment have used the data from *Informationweek* [2, 3, 7, 19]. We can get only the annual IT budget data for the seven-years period from 1991-1997 in *Informationweek* magazine [15].

We use *Forbes* as a data source of performance for the ease of access to financial information at a comparative low cost. Various financial measures are analyzed and provided in the 'Annual Report on American Industry' section of *Forbes* magazine [9, 10, 11].

We use the pooled data that have elements of both time-series and cross-sectional data because we cannot get longer time-series for a longitudinal study. The final sample was comprised of 81 firms with consecutive 5-year IT investment terms on the cross-sectional side. Also, on the time-series side our sample was for three-years, 1995-1997.

Independent and Dependent Variables

Following previous studies about the relationship between IT investment and organizational performance [3, 12, 20, 26], we use the IT budget as an IT investment variable. The IT budget is the estimated annual information system budget in year t as a percentage of revenue in year t to normalize for differences in company size. This ratio shows how much a firm is spending on IT compared to its competitors.

As dependent variables we use financial indexes as a reflection of organizational performance since organizations may measure their own value with financial indexes. Following numerous past research (e.g. [28]), we select Return on Equity (ROE), Return on Capital (ROC), and profit margin as measures of profitability. Also, we use the rate of sales growth and the rate of Earning Per Share (EPS) growth as the index of a firm's growth.

Hypothesis

The focus of this study is not the effects of non-IT factors such as salespersons, advertising, and R&D, but only the effects of IT investment (Figure 1). Therefore, the single most important question that many a researcher has tried to get an answer for is being tested in the first hypothesis. As we saw in the introduction section, they cannot find consistent empirical evidences about the effects of IT on organizational performance.

Hypothesis 1. There is a positive relationship between IT investment and organizational performance.

Though many a study has tried to find a positive relationship between IT investment and organizational performance, the results of previous research have been inconsistent. Many researchers have suggested that one of the limitations in their studies was not considering the time lag between IT investment and organizational performance [22, 24, 28]. If the time lag is included in their research model, research results may be more concrete, consistent, and significant. In addition, Jurison [16] emphasized the longitudinal characteristics of IT investment with the study result that the organization can get the largest payoff after the installation of the information system about 2 years later. IT projects, which are implementing enterprise information systems, not only take a long time in general, but also longer to show their effect on organizational performance. Such a situation appears in Figure 1. Organizational performance at year t (OP_t) is influenced by the sum of IT investment at year t, t-1, t-2, ..., t-k (IT_t, IT_{t-1}, IT_{t-2}, ..., IT_{t-k}) simultaneously. Longitudinally considering IT investment and organizational performance with time lag, we can find easily a consistent positive effect of IT investment. This is related to subject of the second hypothesis.

Hypothesis 2. Both immediate effects and lagged effects between IT investment and organizational performance are positive.

All industries will not be influenced by IT in the same degree [25]. If the core process of a firm is not related with information, the effect of IT on firm performance may be low. Industries using a processing technology, such as chemical or utility industries, can be low information-intensive industries. In such industries, organizational

performances are not closely connected with IT, but are closely related to processing equipment or an automated line of production. If IT is not associated with organizational performance in a low information-intensive industry, firms in the sector may not need to invest heavily in IT.

In a competitive environment of electronic commerce or online trading through the Internet, IT investment will require shorter time frames for capturing and analyzing payoff or reveal stronger associations with performance than in traditional businesses or chemical industry. When IT is a powerful weapon and can differentiate a firm's products or services from others, IT may provide a competitive advantage to a firm.

Even if we consider the time lag effect, it is quite likely that IT investment does not have influence on firm performance because of differences in the information intensity of different industries. Because researchers have not considered the information intensity of different industries, they might not find consistent empirical results. To analyze accurately the payoff of IT investment, we need to think simultaneously of two concepts, i.e. information intensity of industry and time lag. In the group comprised of high information-intensive industries we may find a larger effect of IT investment than in a low one. That is, the sum of the effect from IT investment in high information-intensive industries may be larger than the total effect in low ones. This is the third hypothesis of our study that researchers have tried to solve to determine the effects of IT investment.

Hypothesis 3. IT investment may exhibit stronger association with organizational performance under time lag in a high information-intensive industry than in a low information-intensive industry.

To measure the real payoffs from IT investment, we already hypothesized that we have to consider the immediate effect and lagged effects simultaneously. Because of the workers' time and effort in absorbing IT, there may be a lag in IT investment and firm performance. As the worker's learning accumulates, the firm performance may be increasing. Jurison [16] surveyed that the perceived timing of maximum organizational productivity improvement is the second year. Moreover, Francalanci and Galal [12] assumed that the lagged effects of IT are larger than the immediate effect. We will find the empirical evidence about their assumption with Hypothesis 4.

Hypothesis 4. The lagged effect of IT investment on organizational performance is larger than the immediate effect of IT investment on organizational performance.

Results

Observation number of variables related to IT investment is 174, and observation numbers of organizational performance variables range from 114 to 166. The mean of IT budget per revenue is about 2.5%, minimum is 0.08%, and maximum is 9.9%.

With the result of Pearson correlation analysis, we found that there are positive relationships among organizational performance variables. This points out that the performance variables used in this research are consistent. In addition, as we expected, there are positive relationships among IT investments in each year. Contrary to our expectations, a positive relationship between IT investment and only the profit margin is found, but in other organizational performance variables we cannot find any positive relationship. Therefore, we can partially accept Hypothesis 1.

Prior to performing the regression analysis, a thoughtful examination about the validity of the basic assumptions is needed. Those preconditions are: 1) the number of observations should be at least 10 times over than the number of independent variables; 2) the regression data do not have an outlier; 3) the data should satisfy the normality, the linearity, homoscedasticity, and it does not have an autocorrelation or a serial correlation; 4) it does not have multicollinearity [13, 14]. First of all, after careful examination of the Histogram, normal P-P plot of regression standardized residual, the scatter diagram of regression standardized predicted value and regression standardized residual, casewise diagnostics for the cases meeting the selection criterion, and Cook's distance statistics, we excluded outliers which the diagnostic analyses indicated were influential from the sample [14]. Furthermore, we checked the normality and the linearity of the data with the scatter diagram. An examination of the Goldfeld-Quandt test [14, 23] and the White's test [13, 14] suggested that our data does not have heteroscedasticity. At the same time, there were no indication that an autocorrelation or a serial correlation was problem with the Runs test and the Durbin-Watson d test [14]. Finally, we carefully examined the possibility of multicollinearity with pair-wise or zero-order correlation coefficient between two regressors, Tolerance and Variance Inflation Factor (VIF), and the Condition Index (CI) [13, 14], and there were no problems. As a result, we can continue the regression analysis because our data have satisfied the above preconditions.

Table 1 shows the result of the multiple regression analysis for sales growth, EPS growth, ROC, and ROE. Especially, in sales growth, there is a negative effect of IT investment. The coefficient of IT investment is -0.302 and significant at the 1% level. The F-value that revealed the fitness of model is 171.192 and significant at the 1% level. Furthermore, adjusted R^2 is 0.508. On the other hand, there are positive effects of IT investment in EPS growth and ROC. As IT investment is increased by 1, EPS growth and ROC are increased by 1.654 and 0.453 respectively, both are significant at the 1% level. In the ROE, we cannot find evidence of a positive effect. Because the F-value is not significant (0.608), we cannot accept the regression model for ROE. Therefore, we are able to conclude there is partial

support for Hypothesis 1 with the result of regression analysis, too.

Numerous researchers have thought and suggested that there may be a time lag between IT investment and organizational performance. However, we could find the time lag effect between IT investment and only profit margin (Table 1 and 2). We found the immediate effect of IT investment on sales growth, EPS growth, ROC, and profit margin. Even though we introduced the lagged effect of IT investment to the regression model with sales growth, EPS growth, and ROC as dependent variable, the adjusted R^2 is decreased, contrary to our expectation. It is difficult to accept that the regression model with lagged effect is the best fitting, so the basic model without time lag can be best fitting for sales growth, EPS growth, and ROC. However, in the relationship between IT investment and profit margin, the adjusted R^2 of regression model with one-year lagged effect of IT investment is increased by 0.037. The coefficient of the immediate effect is 0.390 and significant at the 1% level. Also, the coefficient of the lagged effect is 0.746 and significant at the 1% level. In spite of the addition of longer lagged effect than one-year to the regression model, the adjusted R^2 decreased. We could not find a longer lagged effect of IT investment than one-year, so we were forced to stop from going to a longer lag. The one-year lagged model is best fitting (Table 2). As a result, we could find the immediate effect and lagged effect of IT investment on profit margin at the same time, and we could support Hypothesis 2.

Depending on the specific characteristics of industry, it may be that the industry is sensitive to IT investment. That is, the impact of IT investment cannot be equal in all industries. The effect of IT investment in the financial industry may be larger than in the chemical or food manufacturing industries. Next, we performed the regression analysis on profit margin in a high information-intensive industry and a low one (Table 2). We obtained the statistically significant regression model in the high information-intensive industry (F value = 333.384***), and the explanation power of the model is 0.839. When we add the one-year lagged effect of IT investment to this basic model, not only an immediate effect of IT investment but also the lagged effect is positive and statistically significant at the 1% level. In addition, the F value is significant at the 1% level (1243.132***), and the explanation power of the model is increased from 0.839 to 0.975. Although we continue to introduce a longer lagged effect (i.e. two-years lag) to the model, we can get no further. Even though we introduce a longer lagged effect to

Table 1 - Results of Multiple Regression with IT Investment Budget for Sales Growth, EPS Growth, ROC, ROE

	Sales growth		EPS growth		ROC		ROE	
	k=0	k=1	k=0	k=1	k=0	k=1	k=0	k=1
α	9.016***	9.248***	4.644***	5.060***	10.608***	10.676***	15.777***	15.789***
β_0	-.302***	-.027	1.654***	.501***	.453***	.511*	-.065	.026
β_1		-.375***		1.146***		-.089***		-.090
N	166	166	137	137	166	166	114	114
Adjusted R^2	.508	.352	.403	.380	.834	.816	-.003	-.006
F-value	171.192***	45.844***	92.669***	42.661***	830.541***	366.176***	.608	.688
Δ adjusted R^2 in time lag		-.156		-.023		-.018		
Note	Best fitting		Best fitting		Best fitting			

Note. The k is lag. *** denotes significant at the 1% level, and * denotes significant at the 10% level.

Table 2 - Result of Multiple Regression with IT Investment for Profit Margin

	Total industry			High information-intensive industry			Low information-intensive industry		
	k=0	k=1	k=2	k=0	k=1	k=2	k=0	k=1	k=2
α	4.938***	4.502***	4.511***	3.987***	3.111***	3.175***	5.788***	5.606***	5.649***
β_0	.917***	.390***	.409***	1.329***	.585***	.511***	.396***	.115	.374***
β_1		.746***	1.661***		1.008***	1.355***		.387***	1.661***
β_2			-.979***			-.294***			-1.564***
N	158	158	158	65	65	65	93	93	93
Adjusted R^2	.912	.949	.713	.839	.975	.960	.641	.566	.985
F-value	1627.567***	1476.501***	130.833***	333.384***	1243.132***	515.773***	165.388***	60.997***	1956.724***
Δ adjusted R^2 in time lag		.037	-.236		.136	-.015		-.075	.419
Note		Best fitting			Best fitting		Best fitting		

Note. The k is lag. *** denotes significant at the 1% level, ** denotes significant at the 5% level, and * denotes significant at the 10% level.

the model, the explanation power is decreased (-0.015), and the coefficient of the two-year lagged effect changes from a positive sign into a negative one. Therefore, we can accept the model with a one-year lagged effect is the best fitting model. Even if we could not find a longer lag than one-year, we could find the lagged effect of IT investment on organizational performance in a high information-intensive industry. In a low information-intensive industry, we can find the positive effect of IT investment at the 1% significance level (0.396***), too. When we introduce the one-year lag effect of IT investment in the model, the immediate effect of IT investment is no longer statistically significant. In addition, the adjusted R^2 is decreased. In a low information-intensive industry, the best fitting model may be a basic model without any lagged effect.

Moreover, to compare the difference of regression models between in a high information-intensive industry and a low one, we analyzed equation (2). The differential slope coefficient of the immediate effect in the basic model without time lag is 0.933 and significant at the 1% level (Table 3). Furthermore, the different slope coefficients of immediate effect and lagged effect are 0.471 and 0.621, both at the 1% significance level (two tailed test). Therefore, we conclude that the size of the effect from IT investment in a high information-intensive industry is statistically significant larger than in a low one. As a result of this, we cannot reject Hypothesis 3.

Table 3 - Testing the Equality of Two Regressions in a High Information-Intensive Industry and a Low One

	k=0		k=1	
	Coefficient	S. D.	Coefficient	S. D.
a_1	5.788	(0.024)***	5.606	(0.100)***
a_2	-1.801	(0.249)***	-2.495	(0.214)***
b_0	0.396	(0.031)***	0.115	(0.084)
b_1			0.387	(0.093)***
c_0	0.933	(0.079)***	0.471	(0.134)***
c_1			0.621	(0.138)***
N	158		158	

Note. The k is lag. *** means that t-value is significant at the 1% level (two tailed test)

We can easily see that in the total sample the lagged effect is larger than the immediate effect (Table 4). The t-value for testing the equality of two regression coefficients is significant at the 1% level in one tail (0.746*** > 0.390***). Also, in a high information-intensive industry we got a similar result at the 5% significance level in one tail (1.008*** > 0.585***). In a low information-intensive industry, though the coefficient of the immediate effect is not statistically significant, the lagged effect is larger than the immediate effect at the 10% significance level in one tail (0.387** > 0.115). Thus, we could find that the coefficient of the lagged effect is larger than the coefficient of the immediate effect for all types of sample after the t-test. Therefore, we can accept Hypothesis 4.

Table 4 - Testing the Equality of Two Regression Coefficients

	Total industry		High		Low	
	Coefficient	S. D.	Coefficient	S. D.	Coefficient	S. D.
β_0	0.390	(0.036)	0.585	(0.104)	0.115	(0.084)
β_1	0.746	(0.039)	1.008	(0.100)	0.387	(0.094)
Cov (β_0, β_1)	-0.00121		-0.0099		-0.00691	
t-value	4.91936	***	2.0989	**	-1.57799	*
N	158		65		93	

Note. *** means that t-value is significant at the 1% level (one tailed test); ** means that t-value is significant at the 5% level (one tailed test); * means that t-value is significant at the 10% level (one tailed test). High means high information-intensive industry, and Low means low information-intensive industry.

Conclusions

Our research is a firm-level and empirical analysis. The relationship between IT investment and organizational performance was studied without time lag, and then time lag and information intensity of industry were added in our research model. We obtained several findings in this study. First of all, we found that not only is there a positive relationship between IT investment and organizational performance, but also IT investment has an influence on organizational performance. Second, IT investment not only has an instantaneous effect, but also a lagged effect on organizational performance. That is, the effect of IT investment is not a simple one-time event but a continuous phenomenon. Furthermore, when we included the information intensity of industry to our model, we found that the effect of IT investment in a high information-intensive industry is larger than the effect of IT investment in a low one. Firms in a high information-intensive industry have to be more sensitive about IT investment than firms in a low one. Therefore, firms in a low information-intensive industry such as the chemical industry or mining industry might be concerned about other critical factors such as the process technology rather than IT investment. This result is consistent with studies other researchers have performed. Finally, after performing an equality test on the immediate effect and the lagged effect from IT investment, we found the lagged effect from IT investment is larger than the immediate effect because of the learning about IT.

We try to suggest the solution to the IT productivity paradox that some researchers pointed out in their study. With a time lag between IT investment and organizational performance, the paradox disappears. First of all, while we found a negative effect in IT investment and sales growth, we found positive effects in IT investment and profit-related performance variables. If IT investment is not for a firm's growth but for a firm's efficiency such as a cost reduction, they may fail to find a positive effect of IT

investment on firm performance related to growth. Second, if someone uses the sample from a low information-intensive industry, they can fail to get a positive effect from IT investment. Third, if they measure the only immediate effect from IT investment, they can miss the real effects of IT investment. Finally, if they try to find empirical evidence with industry-level analysis, they may fail to find it because in industry-level data there are firms that have neglected to invest in IT.

In this study, there are some limitations. First of all, it is possible to use the restrictive approach because we have only annual data for 7 years and the period of analysis may be too short to consider the complete lagged effects of IT investment [14]. If we get longer and richer data, we can overcome this limitation. Second, we considered the linear relationship between IT investment and organizational performance. If IT investment is increasingly unlimited, organizational performance can be increasingly unlimited. It is difficult for this to happen in the real world. There may be a boundary line or a saturation point beyond which the performance cannot increase with more IT investment. However, the linear relationship is the first step of the study about both the immediate effect and the lagged effect in IT investment and organizational performance. A study has to evolve from a simple concept (linear relationship) into a complex concept (non-linear relationship, e.g. S-shape curved model). Third, the firms in the sample are comparatively heavier IT investment firms, so it may not be a random sampling method. However, we can publicly get the IT investment data from heavier IT using firms. Firms should publicly announce financial data such as revenues, profits, so we can easily get them. On the contrary, the budget or information about IT investment is not obligatory reporting, but an internal management activity and strategy. We can publicly get information related to IT investments such as IT budgets, computer capital from *Informationweek* and *Computerworld* magazines [2, 3]. Many researchers doing firm-level analysis have used the same data sources. Various studies with the same sources can solidify the results of the study. If we can find other sources, we can add lighter IT investment firms to our sample. Finally, the sample period may be outdated. The early nineties may not be in keeping with the new millennium because IT investment at the present time is related to e-business on the Internet. IT budgets in firms can be invested IT in the items most suitable for them. In this study, we do not focus on the payoffs from any specific information systems, but focus on the firm-level performance from IT investment. We do not care about their information systems design, e.g. host based, client-server based, web based. This limitation is related to the data source, too.

In spite of some limitations, with our study we can say with fair certainty that there are payoffs from IT investment. As a result of our study, it may be necessary to increase IT investment for increasing a firm's performance. Also, there is a time lag effect in IT investment and firm performance, so managers have to wait for a specific time to get the long-term payoff from IT investment.

When they evaluate the payoffs from IT investment, they have to consider not only the immediate effect of IT investment but also the lagged effect. We might find the possible answer to solve the IT productivity paradox. If a firm only invests in IT and just waits for the payoffs, will the payoffs be realized? Though some users change Cathode Ray Tube (CRT) monitors to Liquid Crystal Display (LCD) monitors, which the price is over 2 times the CRT monitor's price, their productivity may not increase and a firm cannot get any payoffs from IT investment. This situation may be related to IT productivity paradox. In IT investment, the efforts to plant trees and to grow them are needed. Many huge projects about enterprise information systems have been implemented, are progressing, and will be started. Though much IS project has been finished, a major portion of implemented IS cannot be operated with initial plans [33].

When firms overcome the resource barriers, knowledge barriers, and usage barriers that may be hindering conversion from potential payoffs to realized payoffs, and when firms overcome industry barriers and organizational barriers such as in the study of Chircu and Kauffman [6], firms invested in IT can get realized performances. Our results show that IT investment in firms has a positive impact on organizational performance with an immediate and time lag simultaneously. However, we have to say that when firms' managers who accepted our results decide to invest in IT as a strategic weapon to compete with competitors, they should pay attention to the interpretation of our results. If they just wait for the payoffs after IT investment, they cannot get any benefits. Because IT investment is not a sufficient condition but a necessary condition, organizational performances are not automatically increased with increasing IT investment. When firms have superior capability to convert from IT investment to realized performance and increase their IT investment, their performances can be really increased.

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