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A COMPARATIVE STUDY ON THE TIME LAG EFFECT OF INVESTMENTS IN INNOVATIVE INFORMATION SYSTEMS

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ABSTRACT

The IT productivity paradox is a phenomenon in which productivity doesn't increase proportionally to IT investments. This discrepancy might be a result of the lag associated with learning and adjusting to a new technology. Information systems investment performance improves only after members or users learn and adapt to it. Nevertheless, many existing performance evaluation models cannot draw clear conclusions because they do not consider the time lag. This time lag can cause many problems such as a reduction in investments, change in informatization plan, or eventually failure of its implementation. Therefore, we propose a performance evaluation framework considering performance layers and time lags. We classify time lags into VTL (vertical time lags) and HTL (horizontal time lags) and classify existing indicators into the two categories. We identified time lags from the vertical perspective such as input, process, and output layers and also time lags in each layer from the horizontal perspective. These time lags might differ slightly across countries, and the type of system. A comparative study showed that there was a three-year HTL for WORKNET in Korea, and VTLs of one year for valve companies and one year for Amazon.com in the U.S.

Keywords: *Time-lag effect, Performance evaluation, IT performance, Performance model, IS investment*

1. INTRODUCTION

There have been several studies examining the relationship between IT investments and performance. Those studies present either negative or positive perspectives. From the positive perspective, IT investments are positively correlated with organization performance in increasing ROI, labor productivity, and efficiency through cost savings, and decreasing errors [4,6,7,9,40,53]. On the contrary, some results of the negative studies showed there is no meaningful correlation between IT investment and its performance, but some authors reported negative correlations between the two [5,20,34,49,50]. The phenomenon in which the productivity does not proportionally increase despite an increase in IT investments is called as the controversial IT productivity paradox. It is a recently emerging issue [6,7,8].

There have been several researches to explain the paradox. Among them, Brynjolfsson attributed the contradictory correlation findings between IT investment and its performance to the following four factors: "Mismeasurement of output and input," "Lags due to learning and adjustment," "Redistribution and dissipation of profits," and "Mismanagement of information and technology." [6]. Among these factors, we intend to focus on "Lags due to learning and adjustment." The performance of information systems cannot be expected to immediately improve an organization's performance as such an improvement is possible only after users learn and adapt to the information system [2,6,25,33,48].

However, most previous performance evaluation models have not yielded clear assessments because they do not consider the adoption stages of information systems [16,26,31,35,37]. Dikolli and Sedatole (2007) found out the following limitations of previous performance evaluation models and evaluation indicators: (1) measurement, (2) timing, (3) interaction, (4) functional form, and (5) mediation. Specifically, the performance evaluation that does not take into account time lag would underestimate information system performance [16]. This underestimation may result in decision-making issues resulting in changes in informatization plan, a reduction in investments, or failed information system introduction. Therefore, an organization has to identify the current adoption status of information systems and conduct

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appropriate evaluations and interpretation using a comprehensive performance evaluation model.

Nonetheless, many previous researches have only mentioned the existence of a time lag, and there are few empirical studies on the influence of time lag on actual performance after investment in information systems. Organizations also do not consider the time lag associated with information systems performance and focus only on the evaluation itself when assessing their information systems [16,26,35,37,46]. This omission is because of the lack of a proper framework accounting for time lag with which to evaluate the performance of information systems after investment [30]. Therefore the aim of this study was to suggest a framework for identifying time lags in performance after investment in information systems and to demonstrate the existence of a performance time lag in cross-sectional and chronological dimensions (vertical and horizontal perspectives).

Section 2 describes related studies including those examining the performance of information systems and time lags, and Section 3 suggests a framework to evaluate the performance of information systems considering time lags. It also addresses related performance indicators and the method utilized to verify the model. Section 4 discusses some applications of the framework using WORKNET in Korea and the valve industry and Amazon.com in the U.S. Section 5 provides concluding remarks.

2. RELATED PREVIOUS STUDIES

In this section we review previous studies about IS performance and the most referenced performance evaluation model, the PRM framework. This section also explains the time lag concept and approach.

2.1 IS Performance Evaluation

We can define performance as the degree of achievement of pre-assigned goals or organizational or individual missions with regard to tasks, activities, and polices. Performance can be seen as the outcome or output of organization-conducted business activities using available budget and resources. The U.S. General Services Administration defines performance as the flow of input, project, output, outcome, and impact [21]. They classified it as the present (input and project), short-term (output), and long-term (outcome and impact) performance. Hamilton and Chervany (1981) assumed IS provides information and affects procedures, individual performance, and eventually organization performance. They assumed IS evaluation as a part of management control and proclaimed it as a necessary activity to determine whether the goals of IS are achieved [22]. They also classified the evaluation into an effectiveness-oriented perspective (process-oriented evaluation or formative evaluation) for procedures and efficiency-oriented perspective (results-oriented evaluation or summative evaluation) for individual and organization performance.

The factors involved in IS performance evaluation measures have been developed in many ways. DeLone and McLean proposed the IS Success Model, which takes into account system quality, information quality, and service quality. These three qualities can affect intention to use, use, user satisfaction, individual impacts, and organizational impacts [13,14]. Goodhue and Thompson (1995) introduced Task-Technology-Fit, which assesses the degree to which the technology supports user’s tasks [19]. When IT is used, it should fit the user’s tasks in order to have a positive effect on performance. Based on this theory, they proposed the TPC (Task Performance Chain) model, which is based on the fact that Task-Technology-Fit affects procedures and utilization at a personal level, leading to changes in performance. Davis (1989) proposed the TAM (Technology Adaption Model), which examines the effects of perceived usefulness and ease of use on attitude toward technology and intention to use, and eventually use [12]. Poole and DeSanctis (1990) proposed the Adaptive Structuration Theory to explain organizational changes attributed to the use of information technology [44].

The U.S. government introduced the performance reference model (PRM) as the “reference model” or standardized framework used in describing the federal enterprise architecture of the U.S. government to measure the performance of major IT investments and their contribution to program performance. The PRM was designed to serve three main purposes: 1) Produce enhanced IT performance information to improve strategic and daily decision making; 2) Improve the alignment, and better articulate the contribution of IT to business outputs and outcomes, thereby creating a clear "line of sight" to desired results; and 3) Identify performance improvement opportunities that span traditional organizational structures and boundaries [18]. As shown in Figure 1 below, the PRM includes three levels such as Input, Output, Outcome and the following six measurement areas:

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Mission and Business Results, Customer Results, Processes and Activities, People, Technology and Other Fixed Assets.

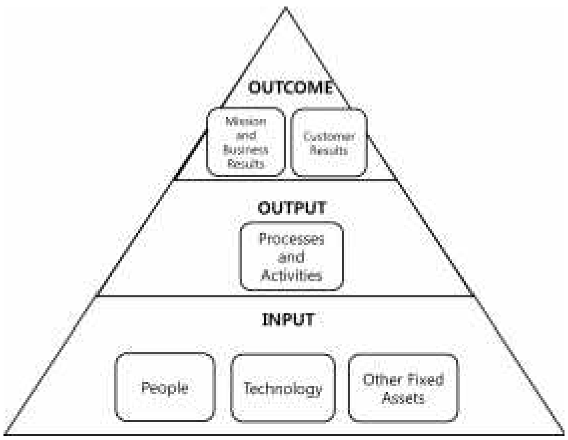

Figure 1: Performance reference model

This model provides a guideline for controlling and managing the unique tasks of institutions in the strategic dimension. Many performance evaluation models adopted this framework. One recent framework based on PRM that includes the time lag concept is the KISDI (Korea Information Society Development Institute) model [25,36]). We also used the PRM as a reference in developing the framework proposed here.

2.2 Time Lag Approach

A time lag is defined as a time delay attributable to a particular property or behavior of individuals, organizations, communities, systems, etc. [11]. It means that the effects on outcomes differ significantly depending on the order in which causal variables are applied, although the same variables in a causality function are used, and the size and direction of causality is also markedly different depending on the maturation stage [38] of the organization and the changing path of the variables.

With a time lag approach, two major timing categories are assessed. One is when the effect of elapsed time should be considered in the causality and the other is the influence of time lag on the causality with varying causal variables [11]. The time context decisively influences causality and taking into account time lags enable us to identify problems that can occur when we introduce new elements before setting a system. The time lag may differ across systems [25].

Many previous studies attempted to explain the productivity paradox phenomenon using conceptual models, causal analyses, empirical studies, etc., but overlooked the effect of time lag on performance. Although researchers have mentioned the existence of time lags in reference to certain variable properties or behavior in the IS performance, none have examined these relationships in detail. As such, it is difficult to explain how much time has elapsed after the onset of independent variables or what effect the elapsed time has on the process of IS introduction. To address this deficiency, a performance evaluation framework is needed to allow time lag analysis in a systematic performance evaluation. Empirical studies are also needed to determine when specific variables yield results and for how long certain factors influence outcomes depending on changing causal variables.

Recently Lee(2011) proposed a framework including time lag for the performance evaluation [30]. This article will introduce this framework and verify it by showing some comparative examples of Korea and the U.S cases.

3. PROPOSED TIME LAG FRAMEWORK

3.1 Performance Layers and Indicators

After categorizing variables from previous literature, we classified them into input, process, and output levels. The input layer refers to “System & Environment” as the investment and the process layer includes “Individual Performance” and “Change in Workflow” and the output layer refers to “Organizational Performance.” Previously researched factors associated with IS performance can be categorized in one of these three. Based on previous studies, we also made an indicator pool by summarizing previous performance indicators as Table 1 [30].

The input layer covers following previous researches: Information provision in [22], external variables in [12], system quality, information quality, service quality in [13,14,23], characteristics of tasks and technology in [19], input, project in [21], and people, technology, and fixed assets in [18]. We summarized them into five factors, system quality, information quality, service quality, human resources, and financial resources, and some representative examples of indicators are listed in Table 1.

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Table 1: Performance layers and evaluation indicator pool for IS performance (revised from [30])

Layer	Definition	Factor	Indicators	Previous Studies
Output	Organization's performance through the utilization of IS	Achievement of organizational mission	Degree of achieved performance goals, processing capability, connectivity among ministries or departments, workload reduction, improved business knowledge , business efficiency, transparent business processes, easy to work, and degree of business improvements, etc.	[27,29,33,36,54]
		Improvement of organizational image	Informatization effects, improved reliability, and improvement of awareness, etc.	[10,15,51]
		Customer benefits	Customer satisfaction, number of reported dissatisfaction, reliability level, providing effective information, number of utilization of service, and costs of service etc.	[3,14,33]
Process	Individual performance through the utilization of IS	Work efficiency	Overall performance, processing capabilities, service speed, work efficiency, business alignment, number of providing services per hour, treated tasks per person, number of produced services per person, interoperability, accessibility, business support, information sharing, employee satisfaction, etc.	[1,3,17,24,27,32, 36]
		Business capabilities	The speed of decision-making, quality of decision-making, work quality, knowledge management, work security, Number of user, frequency of use, financial management etc.	
Input	Invested resources or operations for the quality and development of IS	System quality	Convenience, availability, security, response time, system reliability, number of disability incidence, system backup cycles, etc.	[13,14,22,28,37,4 2,32,52]
		Information quality	Accuracy, timeliness, usefulness, sufficiency, information quality, ease of understanding, reliability of information, error data rates, missing data rates, periodic data updates, etc.	[13,14,33,39,45]
		Service quality	Responsiveness of service, IS provider reliability, IS providers specialty, etc.	[14,28,37,41,43]
		Human resource	Informatization leadership, informatization capability, IT perception level, organizational structure, organizational culture, training, etc.	[12,22,47]
		Financial resource	IS deployment costs, maintenance costs, training support costs, administrative costs, cost of using, etc.	

The process layer covers the following previous studies: Procedures and individual performance in [22], intention to use and use in [12], intention to use, use, user satisfaction, individual impact in [13,14], task-technology fit, utilization in [19], short-term output in [21], and processes and activities in [18]. We summarized them into two factors, work efficiency and business capabilities.

The output layer covers the following researches: Organization performance in [22], net benefits, organizational impact in [13,14], outcome, impact in [21], mission and business results, customer results in [18]. We summarized them into three factors, achievement of organizational mission, improvement of organizational image, and customer benefits.

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In this study we chose several applicable indicators from the indicator pool to demonstrate VTLs and HTLs in performance changes for the example cases.

3.2 Time Lag Framework

The purpose of this research is to demonstrate the existence of a time lag in quantifiable performance improvement after information system investment. Previous studies tried to explain the time lag only from a chronological viewpoint. We surmise that time lag can exist in a certain level of performance layers and between certain performance levels. To demonstrate this, we developed a framework for information systems performance evaluation as shown in Figure 2 [30]. This framework consists of time lag factors in the performance level of two major dimensions: VTL (vertical time lag) and HTL (horizontal time lag).

VTL refers to the time until a change in performance appears through the performance layers following the flow of input → process → output layers. The time lag factors affect the hierarchical causal relationship through the performance layers. HTL refers to the time lag of a specific performance indicator in a certain layer. We defined the time lag factors as *Ti, Tp, To* according to each layer as specified below. *t* refers to a specific time point.

- *t + n* is n time units that have passed after a certain time t
- *Input(t), Process(t), Output(t)* refers to the performance of a specific time t.
- *Ti* is the time lag of the performance change in the input layer that appears after n time units have passed
- *Tp* is the time lag of the performance change in the process layer that appears after n time units passed
- *To* is the time lag of the performance change in the output layer that appears after n time units have passed
- *Tip* is the time lag of the performance change in the process layer that is affected by *Input(t)* after n time units have passed
- *Tpo* is the time lag of the performance change in the output layer after n time units have passed that is affected by *Process(t)*
- *Tio* is the time lag of the performance change in the output layer that appears after n time units have passed that is affected by *Input(t)* and *Process(t)*. In general *Tio = Tip + Tpo*

In summary, this framework defined the time lags between two layers as *Tip, Tpo, Tio* in the VTL dimension following the causal flow of input, process, and output and the time lags of specific indicators as *Ti, Tp, To* in the HTL dimension.

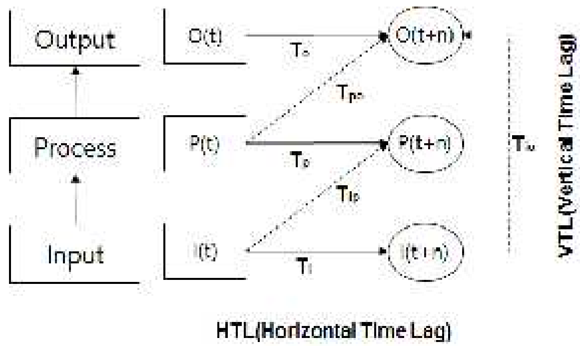

Figure 2: Proposed framework for information systems performance evaluation from the viewpoint of time lag (revised from [30])

3.3 Verification Method

One easy way to demonstrate the existence of a VTL is to conduct an event analysis. If we can show there is a time gap between the investment and performance change in a certain layer we can show the time lag intuitively (*Tio, Tpo*). To verify the existence of a time lag between layers, we can set up a research model and derive hypotheses based on existing theory in order to demonstrate a causal relationship in the VTL dimension through the layers.

To demonstrate a time lag effect in the HTL dimension, we can also design a research model and set up hypotheses. By collecting related data and analyzing it, we can verify these hypotheses.

In this study we will perform event analysis on VTLs and verify hypotheses of the existence of HTLs by using t-test.

4. COMPARATIVE EXAMPLES OF APPLYING THE FRAMEWORK

4.1 Examples of VTL Cases

4.1.1 The U.S. traditional valve industry (*Tio, Tpo*)

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Peter Weill (1992) did an empirical test by analyzing six years of historical IT investment and performance data from 33 small and medium valve manufacturing firms in the United States as Figure 3 [53]. He studied IT investment by categorizing strategic, informational and transactional effects with four measures of performance (sales growth, return on assets, and two measures of labor productivity).

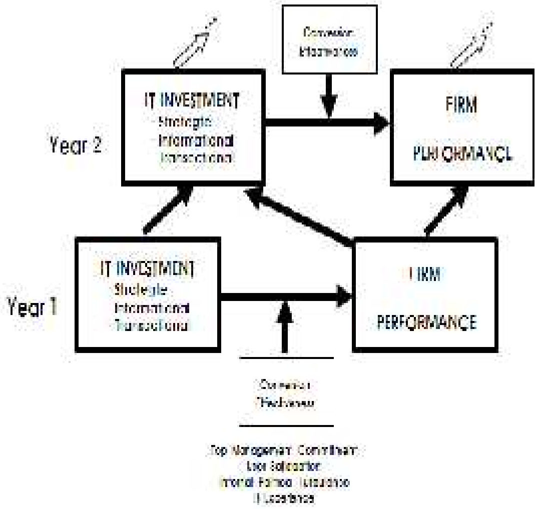

Figure 3: Peter Weill 's research model (Weill, 1992)[53]

IT investment in the valve industry grew from 3.4% to 4.0% of sales over the six-year period as Table 2. He measured sales, growth, ROA, employees, labor, and market share as performance indicators and the results are as follows:

- There were no associations between previous years′ total investment in IT and the firms′ incremental performance.
- However, there were positive relationships between the transactional IT investment of the previous year and the performance of the current year (*Tio*).
- Conversion effectiveness, which measures the quality of the firm-wide management and commitment to IT, was found to be a significant moderator between strategic IT investment and firm performance (*Tpo*).

Table 2: Average IT investment of the surveyed companies (% of sales) (Weill, 1992) [53]

	Year					
Investment	‘82	‘83	‘84	‘85	‘86	‘87
IT	3.4	3.7	3.7	3.7	4.0	4.0
Strategic IT	0.4	0.5	0.6	0.7	0.9	0.9
Informational IT	2.1	2.2	2.1	2.0	2.2	2.2
Transactional IT	0.9	1.0	1.0	1.0	0.9	0.9

The relationship between investment in IT and firm performance is complex and circular in nature [53]. This study showed that cross-sectional studies may provide a misleading snapshot of this complex relationship and there are some time lags between the investment and its effect on performance in U.S. companies, which supports the existence of *Tpo* and *Tio*.

4.1.2 The U.S. online company, Amazon.com (*Tio*)

Amazon.com is the world's largest online bookstore and one of the world's largest Internet retailers founded in 1994 by Jeff Bezos. It provides effective personalization strategies in accordance with customer preferences (one-to-one marketing) by using customers’ historical profile data as well as feedback or product evaluations. Amazon.com has been leading the pioneering role of e-commerce as a dot-com myth. Amazon.com has expanded beyond items from books to music and DVDs and has showed an annual growth rate of over 200% from 1995 to 2000 before the dot-com crash. After suffering restructuring and diversification, it became an Internet shopping mall selling music, toys, games, software, and electronic products with aggressive low-cost policies. It also introduced the e-book “Kindle” and AWS (Amazon Web Services).

Table 3 shows Amazon's revenue and investment in technology and content since 1996. Discarding some events or detailed content of investments, we focused only on fluctuations in the year-to-year increased ratio in Figure 4. As we can see in Table 3, the increased investment ratios of 1997, 1998, 1999 compared to other years might have resulted in the high revenue ratios in 1998, 1999, 2000. Amazon.com started online sales of toys, electronics and software in 1997, launched the first

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international sites (co.uk & de) in 1998, and opened its used item market in 1999. Another notable change in investment ratios happened in 2005, 2006, which may have resulted in the revenue increases of 2006, 2007. Amazon.com started its PRIME membership in 2005 and cloud AWS (Amazon Web Services) in 2006 and sold the first Kindle e-reader in 2007. During 2010 and 2011, Amazon launched a price check barcode-reader app and the Kindle Fire tablet, and its revenue ratios increased around the same time. Based on this observation we expect that a time lag occurred after about one year of Amazon.com's investment in IT.

Table 3: Revenue and investment in technology and contents of Amazon.com (millions $)

Year	Revenue	YoY	Technology & contents Expense	YoY
1996	157		2	
1997	148	-6%	13	460%
1998	610	313%	46	249%
1999	1,640	169%	160	244%
2000	2,762	68%	269	69%
2001	3,122	13%	241	-10%
2002	3,933	26%	216	-11%
2003	5,264	34%	208	-4%
2004	6,921	31%	251	21%
2005	8,490	23%	451	80%
2006	10,711	26%	662	47%
2007	14,835	39%	818	24%
2008	19,166	29%	1,033	26%
2009	24,509	28%	1,240	20%
2010	34,204	40%	1,734	40%
2011	48,077	41%	2,909	68%
2012	61,093	27%	4,564	57%
2013	74,452	22%	6,565	44%

4.2 Examples of HTL Cases

4.2.1 Korea 'WORKNET' case

'WORKNET'(www.worknet.go.kr) is the most famous job information portal site provided by the Korean government. The Ministry of Labor of Korea makes an effort to improve public service, and 'WORKNET' provides necessary information for enterprises, training institutions, citizens including trainees, and customized services with various information menus and enhanced content such as job training information, eligibility information, and national support information. 'WORKNET' launched its early Internet-based version in 1998, changed to the current web-based portal service in 2004, and consistently has been enhancing its services since then. As a result, average daily visitors reached 467,000 in 2013. In terms of job and HR information, 3,912110 people are registered for the job search and 2,551,322 firms are registered for recruitment. Looking at the status of members, 9.3 million people are registered on 'WORKNET' with 8.24 million personal members, one million corporate members and 6,766 job placement staff in local employment support centers. We gathered DB data for analysis from 2002 to 2013 including 72 national employment centers and 392 WORKNET users. We collected DB data from 'WORKNET' system with regard to three indicators from a system manager and conducted a survey about reduced processing time targeting 392 officers using the 'WORKNET' system.

We selected the following three indicators to examine HTL: Number of 'WORKNET' users in the input level, reduced task processing time in the process level, and employment rate through 'WORKNET' in the output level. Indicators from each level were already proposed in the previous section and have been proven in previous studies related to informatization performance evaluation. Based on the selected indicators, we developed a questionnaire to target employment information service and job centers. To demonstrate the time lag effect on the HTL level, we conducted a trend analysis and mean difference verification for the periods.

4.2.2 Input (*Ti*) level: 'Number of WORKNET Users'

We used the 'number of 'WORKNET' users to demonstrate the time lag effect on the input (*T*i) level. Table 4 summarizes the investment budget for WORKNET and some performance data from 2002 to 2013. There were relatively high investments in 2002, 2004, 2006, 2008 and 2011 compared to other years. From 2002, which was the starting point of WORKNET, the number of users decreased until 2004 and then continuously increased after 2005 as Figure 5.

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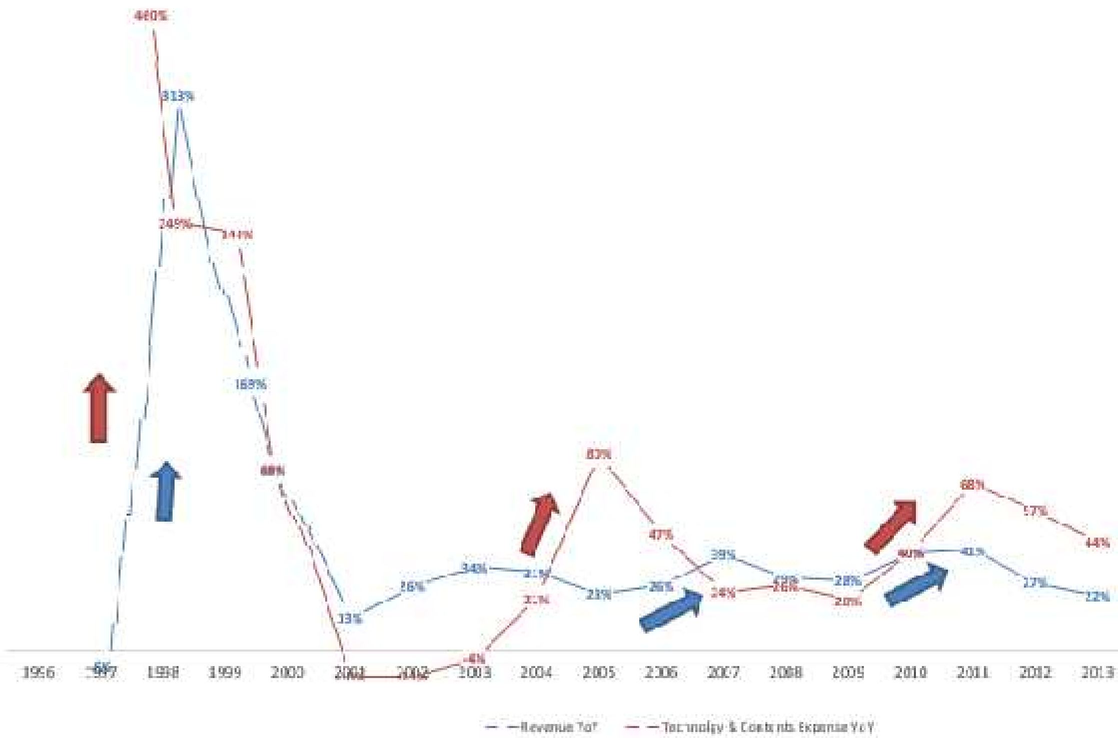

Figure 4: Annual trends in revenue and investments of Amazon.com (YoY)

Table 4: Annual trends data for WORKNET

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
New proposal for recruit	1,221,799	960,535	841,262	866,013	915,178	1,151,052	1,249,837	1,456,516	2,173,391	2,154,163	2,307,710	2,551,322
New request for job	1,672,462	1,575,143	1,510,554	1,686,708	1,872,668	2,230,916	2,361,669	3,256,415	3,390,254	3,284,664	3,381,325	3,912,110
No. of users	2,894,261	2,535,678	2,351,816	2,552,721	2,787,846	3,381,968	3,611,506	4,712,931	5,563,645	5,438,827	5,689,035	6,463,432
YoY (%)		-12.4	-7.3	8.5	9.2	21.3	6.8	30.5	18.1	-2.2	4.6	13.6
Budget (Million $)	15.2	10.5	13.7	14.6	18.4	19	24.2	21.3	15.3	23.2	21.8	24
YoY (%)		-30.9	30.5	6.6	26.0	3.3	27.4	-12.0	-28.2	51.6	-6.0	10.1

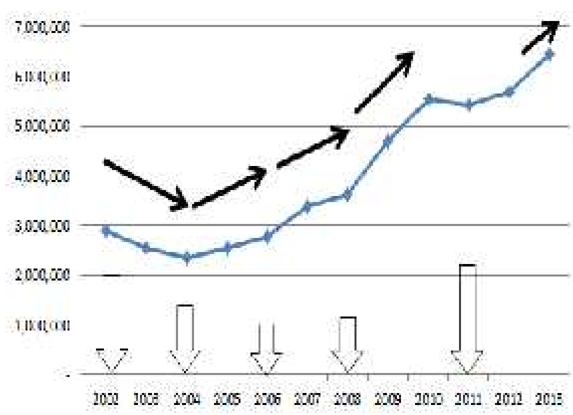

Figure 5: Annual trends in 'WORKNET' users

We gathered monthly number of WORKNET users from 2002 to 2013 as Table 5 and conducted mean difference verification based on 2002 as Table 6. It indicates the number of WORKNET uses had decreased until 2004 and then increased again from 2005. We can explain this phenomenon based on reluctance to use the new system during the initial adoption stage. Based on these results, we presume that it takes about three years until the performance indicators of input (*Ti*) appear, which supports the hypothesis that there is a time lag on the input level.

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Table 5: Monthly number of WORKNET users from 2002 to 2013

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan	268,549	228,564	202,240	230,612	216,451	295,394	316,251	325,269	429,393	445,462	446,912	571,016
Feb	261,411	252,989	237,933	189,983	238,341	241,228	273,602	371,772	396,758	395,794	474,809	438,390
Mar	254,537	239,585	275,812	287,480	259,694	317,499	349,497	422,619	577,086	559,971	524,155	558,411
Apr	270,130	222,751	182,930	207,576	203,069	290,860	304,516	386,388	489,001	459,488	463,182	528,469
May	231,105	193,071	166,759	192,900	206,318	279,257	267,361	337,172	417,805	433,825	484,071	513,175
Jun	198,822	181,432	203,122	226,633	244,880	270,803	302,701	456,774	517,577	492,959	471,727	629,139
Jul	194,882	192,195	187,944	199,274	212,487	287,018	316,182	408,453	484,021	434,873	465,748	572,779
Aug	245,445	206,383	182,782	207,791	223,398	285,065	263,021	394,004	487,949	453,216	470,089	520,105
Sep	249,616	203,178	168,910	216,741	247,604	248,019	310,567	439,192	429,637	444,912	454,467	514,923
Oct	261,900	221,544	183,333	203,659	244,272	341,820	310,791	381,471	467,781	437,722	544,094	592,023
Nov	249,459	202,488	165,786	186,430	263,795	291,656	273,689	353,992	425,309	442,274	478,831	496,242
Dec	208,404	191,497	194,265	203,642	227,537	233,349	323,328	435,823	441,328	438,331	410,950	528,760
Total	2,894,261	2,535,678	2,351,816	2,552,721	2,787,846	3,381,968	3,611,506	4,712,929	5,563,645	5,438,827	5,689,035	6,463,432

(note: monthly data for 2002 and 2003 are estimated from the total number of the year)

Table 6: Annual mean difference verification on WORKNET users through 'WORKNET'

Annual difference validation on WORKNET user compared 2002 as base year	Annual difference		t-value	Significance probability (two-tail)
	Mean	Standard Deviation		
2003	29881.917	16465.358	6.287	.000***
2004	45203.667	38735.827	4.043	.002***
2005	28461.583	35620.445	2.768	.018**
2006	8867.833	31972.524	.961	.357
2007	-40642.333	33099.884	-4.253	.001***
2008	-59770.500	39059.012	-5.301	.000***
2009	-151555.750	60218.595	-8.718	.000***
2010	-222448.750	61180.187	-12.595	.000***
2011	-212047.250	48998.461	-14.991	.000***
2012	-232897.917	35616.348	-22.652	.000***
2013	-297431.000	64795.609	-15.901	.000***

4.2.3 Process (*Tp*) level: 'Reduction in Task Processing Time'

We selected 'Reduction in Task Processing Time' as indicator to demonstrate the time lag effect on the process (*Tp*) level. The data and implications are summarized from [30] for this section. The original data were collected from the survey of 392 public officers in job centers across the country. Only users who had experiences with the 'WORKNET' system in a specific year were asked to respond to the survey. Based on evaluation indicators of 'WORKNET' system performance, we selected registrations processing, certification service, counseling service, placement service, complaints handling processing, and average daily counseling cases for employment support as the evaluation indicators for process (*Tp*) time lag analysis.

We conducted a verification of mean difference to determine whether there were annual differences in task processing time. As shown in Table 7, three indicators (recruitment registration, job registration, and job certification) differed significantly between '03 (base year) prior to the introduction of 'WORKNET' and '05 [30]. A total of seven indicators between '03 and '07, including three indicators between '03 and '05, differed significantly from year-to-year.

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Table 7: Annual change in the rate of reduction in task processing time and mean difference verification (revised from [30])

Dimension	Annual change rate of reduction time of task processing				Verification of mean difference between '03 and '05			Verification of mean difference between '03 and '06		
	Base year Mean	'05 Mean	'06 Mean	Base year Standard Deviation	'05 Standard Deviation	'05 t-value	'05 Sig.	'06 Standard Deviation	'06 t-value	'06 Sig.
Registration time per a recruitment (minutes)	5.27	4.91 (▼6.8%)	4.83 (▼8.3%)	1.469	1.336	3.394	.001*	1.392	3.573	.000*
Registration time per a job (minutes)	5.21	4.89 (▼6.1%)	4.91 (▼5.8%)	1.494	1.298	3.483	.001*	1.425	2.463	.015*
Certification time per a recruitment (minutes)	4.82	4.61 (▼4.4%)	4.43 (▼8.1%)	1.466	1.355	2.438	.016*	1.435	3.782	.000*
Certification time per a job (minutes)	4.81	4.65 (▼3.3%)	4.53 (▼5.8%)	1.382	1.336	1.902	.059	1.403	2.577	.011*
Counseling time per a recruitment (minutes)	14.04	13.86 (▼1.3%)	14.13 (Δ0.6%)	1.358	1.299	.731	.466	1.387	-.355	.723
Counseling time per a job (minutes)	14.25	14.04 (▼1.5%)	13.89 (▼2.5%)	1.406	1.363	.740	.460	1.445	.933	.352
Placement time per a recruitment (minutes)	37.0	37.0 (0%)	39.20 (Δ5.9%)	1.006	1.045	0	1.00	1.114	-2.097	.038*
Placement time per a job (minutes)	22.80	23.3 (Δ2.2%)	23.50 (Δ3.1%)	1.171	1.207	-.767	.444	1.270	-.808	.420
Complaints processing time per a recruitment (minutes)	2.95	2.84 (▼3.7%)	2.69 (▼8.8%)	1.474	1.493	1.930	.056	1.470	3.130	.002*
Complaints processing time per a job (minutes)	2.85	2.81 (▼1.4%)	3.04 (Δ6.7%)	1.505	1.432	.521	.603	1.528	-1.627	.106
Average daily number of employment support counseling (cases)	3.83	3.82 (▼0.3%)	3.53 (▼7.8%)	1.320	1.316	.103	.918	1.329	2.813	.006*

"Counseling time for recruitment/job" was not a statistically significant indicator. This result indicates that this particular variable was not affected by informatization because the counseling process is more dependent upon face-to-face counseling between public officers, employers and employees. As shown in Table 7, the reduction in the time required for registration for recruitment and job search and certification for recruitment and job search, placement time for recruitment, and complaints processing for recruitment were all improved by informatization and continuous investment. A reduction in the average daily number of employment support counseling sessions can be interpreted as a reduction in the counseling workload related to employment because users were able to access necessary information without counseling through 'WORKNET'. On the other hand, placement time per recruitment increased, unlike the other indicators, because the number of employees increased, requiring more information to provide the same service. Our data analysis demonstrates the time lag effect at the process (*Tp*) level, and indicates that it takes more than three years for performance indicators to appear on the process (*Tp*) level. These findings are evidence to support the hypothesis that a time lag exist in process (*Tp*).

4.2.4 Output (*To*) level: 'Employment Rate in 'WORKNET' Systems'

To demonstrate the time lag effect on the output (*To*) level, we selected employment rate through 'WORKNET' as the evaluation indicator. Analysis data from 2002 to 2013 was obtained from the data provided by the Ministry of Employment and Labor of Korea as Table 8.

Table 8: Descriptive statistics for employment rate through 'WORKNET'

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
No. of employment	571,025	522,009	386,154	415,022	485,285	593,573	635,849	864,755	947,097	957,288	1,195,422	1,515,739
Employment rate (%)	34.1%	33.1%	25.6%	24.6%	25.9%	26.6%	26.9%	26.6%	27.9%	29.1%	35.4%	38.7%
YoY (%)		-2.9	-22.9	-3.7	5.3	2.7	1.2	-1.4	5.2	4.3	21.3	9.6
Budget (Million $)	15.2	10.5	13.7	14.6	18.4	19	24.2	21.3	15.3	23.2	21.8	24
YoY (%)		-30.9	30.5	6.6	26.0	3.3	27.4	-12.0	-28.2	51.6	-6.0	10.1

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As shown in Figure 6, the employment rate through 'WORKNET' rapidly decreased starting from 2002 to 2005 and then increased again thereafter. From 2006, the employment rate through 'WORKNET' stabilized and this indicator increased smoothly thereafter.

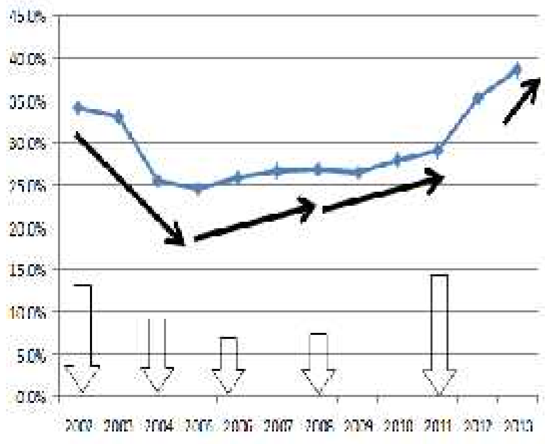

Figure 6: Annual trends in employment rate through 'WORKNET'

As the results of mean difference verification as Table 9, the employment rate had decreased until 2005 and then increased again. These results indicate that 'WORKNET' users started to use the site in earnest for their recruitment or job finding activities after a period of learning and adapting to the 'WORKNET' system. Our data suggest that it takes about three years for indicators to show up at the output (*To*) performance level, which supports the notion that a time lag exists on the output (*To*) level.

5. CONCLUDING REMARKS

The implications of this are both academic and social. In terms of the academic contribution, we provide perspective in understanding information systems performance in terms of time lag. We also proposed a theoretical foundation and framework for evaluating information systems performance while accounting for time lags by examining exploratory hypotheses. We also redefined the performance level of information systems by separating time lag into VTL and HTL dimensions and classified time lags as *Ti*, *Tp*, *To*, *Tip*, *Tpo*, *Tio* and demonstrated the existence of each through empirical analysis. We provided a theoretical foundation to explain the IT productivity paradox as an effect of time lag and demonstrated that investment performance of information systems did not appear in the short-term and had a time lag in each performance level. We confirmed the existence of VTL and HTL by applying the proposed framework to cases from Korea and the U.S. We also attempted to develop a methodology for social science research about the time lag effect. Our framework helps us understand some parameters of time-related innovation factors such as development speed and innovation emergence interval etc. Of course this research can inform guidelines regarding methods with which to study of the time lag effect in social science areas.

Table 9: Annual mean difference verification of employment rate through 'WORKNET'

Annual difference validation on employment rate compared 2002 as base year	Annual difference		t-value	Significance probability (two-tail)
	Mean	Standard Deviation		
2003	1.46667	7.18766	.707	.494
2004	8.70833	8.20393	3.677	.004**
2005	9.32500	5.82504	5.545	.000***
2006	8.53333	6.50026	4.548	.001***
2007	8.13333	5.80021	4.858	.001***
2008	7.45000	7.69717	3.353	.006**
2009	7.90000	6.60826	4.141	.002**
2010	6.94167	5.99188	4.013	.002**
2011	5.61667	5.78381	3.364	.006**
2012	-.60833	5.61386	-.375	.715
2013	-4.14167	5.21213	-2.753	.019**

This study also has several social contributions. First, public organizations can improve their quality of decision-making through information systems

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performance analysis that takes into account the performance level of information systems and emphasizes the importance of the time lag effect. Second, the research model discussed here includes variables impacting organization performance. By using these variables one can determine when the performance variables appear on a particular performance level. Third, our findings suggest that organizations have to consider the time lag for proper performance evaluation of information systems investments. Fourth, this research emphasizes the importance of securing and managing time-series data for proper performance evaluation of information systems. Our examination of the time lag will help to encourage researchers to study related topics, and the results of this study can be used effectively in policy making and education programs.

In this study we focused on the time lag effect on the performance of information system introduction by classifying time lags as either horizontal or vertical with input, process and output layers. Such time lag effects can be observed in many cases whatever it is in domestic or abroad and the time lags might differ depending on the type of system, industry, environment, and country. In this study we were able to estimate a three-year time lag in Ti and a three-year time lag in *Tp* and *To* in Korea WORKNET case. The small valve industry in the United States showed about a one-year time lag in *Tio* and *Tpo*. In addition, the time lag was about one year in the case of Amazon.com.

Even though this was an explorative study, it can be expanded upon to identify differences in time lags according to domains, types of information systems, innovation types, environment, etc. By using more historical data and transactional DB data [32], the time lag effect can be researched in detail more in the future.

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