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Analysis of Efficiency Changes of IT-Service Companies Using DEA-Window

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Abstract

This study investigates and analyzes the efficiency of IT service providers over 7 years. It analyzes the efficiency of companies every year, predicts the direction of efficiency through trend analysis, and considers countermeasures accordingly. In addition, stability analysis is carried out by examining the fluctuation of the efficiency of the company for 7 years. It is possible to consider the measures against the sudden change of efficiency. The purpose of this study is to predict the efficiency and to cope with the change by considering the dynamic efficiency as well as the static efficiency of the enterprise. DEA-Window methodology is applied for this study.

Keywords*: DEA, DEA-Window methodology, Efficiency change, IT service*

1. INTRODUCTION

Recently, domestic IT service market has been growing at a low rate of 1% due to economic deterioration and the maturation of IT level of companies. The global market is also experiencing a low growth of 2-3%. This is because, in times of economic downturn, companies are less likely to invest in their IT infrastructure that is not their core business, or cancel or postpone planned IT projects. It can be seen that the maturity of IT level of companies is related to the level limit of the product or service that existing IT service companies have provided. This is because companies do not feel attracted to products or services that do not offer higher value than their existing IT systems. Due to these causes, the IT service market is shrinking and competition between companies is continuing.Those who are hit first by the low growth of the market are weak middle and small companies whose sales are not stable. Unlike a conglomerate affiliated, there are few special related parties that can expect internal sales. Large corporations also cannot be relied on from a growth perspective, not from survival. The sales that can be expected from related parties are limited in terms of size and type, making it inappropriate to use as a platform for growth. As a result, companies in the IT service market need to improve their level of products or services they have already provided, or expand their business into new business areas.

The Korea Information Technology Service Industry Association (KITSIA) divides the IT service industry into five categories: consulting and development, system integration, outsourcing, IT convergence services, and education and training [11]. If you look larger, you can group it into three areas: consulting and systems integration, outsourcing, support and training. Consulting is the task of establishing a medium- and long-term information plan of a company and advising on solution, network, and facility operation. System integration is the task

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of planning the information system for the enterprise and installing the software and hardware for it. These tasks require a high degree of understanding of the industrial characteristics and business processes to which the company belongs, and it is also important to integrate and integrate with existing information systems. Outsourcing refers to the task of entrusting the IT resources (software, hardware, network, service, etc.) The reason why a company does not operate its own IT resources but entrusts it to a specialized company is because it can concentrate on its main business as well as cost reduction and stability. Support and training is the task of providing software and hardware-related technical support and providing related education / training. In particular, education / training focuses on the application rather than the operation of IT resources.

The global IT services market is expected to grow at an average CAGR of 3.0%, reaching $ 730.5 billion by 2020. In detail, consulting and system integration amounted to 277.9 billion (3.7% CAGR), outsourcing was 284.8 billion (2.3% CAGR), and support and training amounted to 167.8 billion USD (3.1% CAGR). The domestic IT service market will grow to a CAGR of 1.7%, reaching 8.7 trillion won in 2020. In detail, consulting and system integration are 3.6 trillion won (CAGR 1.2%), outsourcing 3.7 trillion won (CAGR 2.2%) and support and training 1.3 trillion won (CAGR 1.4%). Currently, the domestic IT service market is composed of Samsung SDS, LG CNS, SK (formerly SK C & C), which is a comprehensive SI system integrator, and Hyundai Auto Group of Hyundai Motor Group, Growth. Most of these large corporations have a high proportion of internal transactions. This is because the purpose of the establishment is to maintain IT service expertise, efficiency, and security for the industries in which major affiliates operate.In addition, sales to the market are not large, but there are also midsize companies that have their specialized fields as a non-large-scale business. Midsize companies specialize in the relatively less profitable public, defense and finance sectors. This is due to the regulation of the software industry promotion law revision in 2013, which prevents IT service companies (i.e. SI companies, affiliated with large conglomerates) affiliated with mutual investment-restricted business group from participating in the public market in principle.

As the regulation is confirmed to be ineffective, the restrictions on participation in new technologies such as IoT, cloud, and big data have been relaxed through the guidelines of 'the Ministry of Science ICT and Future Planning' in November 2015, It is expected to take three to five years or more before market reorganization takes effect[13].

In this study, we focus on the management efficiency of IT-service companies and evaluate the efficiency of these companies and analyze the changes of efficiency and suggest implications for them.

2. DEA-WINDOW MODEL CONCEPT

The efficiency score calculated through the DEA means the ratio of output to production input utilized by the production organization. It is used as a relative efficiency evaluation method that compares the DMU with the other DMU by assigning the most favorable weight to the DMU to be evaluated and calculating the efficiency. DEA uses the CCR model to evaluate efficiency under the assumption that the scale returns of each DMU are unchanged, and the BCC model to distinguish efficient DMUs by pure technological efficiency, excluding scale efficiency. Based on these models, the DEA-Window model with moving average for each period of data is used for long-term efficiency analysis.

In DEA, when DMU input / output data is collected by period (year, quarter, etc.), efficiency can be grasped roughly from the time

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series perspective by period efficiency score. However, it is difficult to directly compare the efficiency score of a specific period with the efficiency score of another period for each DMU. So Charnesand Cooper [4] suggested a way to compensate for this. Window analysis requires collecting data over a period of time and determining the width of the observation period (called window) to observe dynamic changes. In each window, the same DMU is considered another DMU if the duration is different.

DEA-Window analysis can confirm the trend and stability by performing DEA analysis through moving average. The DEA-Window analysis should determine the width of the period for observing dynamic changes. When the window width is p and the analysis period is k, p is determined using equation (1).

The number of windows (w) is $w = k-p + 1$ as in Table 1. When the width (p) of the window is determined, the window efficiency evaluation is sequentially analyzed through the moving average. That is, when the number of DMUs is n,DMUs from period 1to$p$ are targeted in the first window, and pn DMUs from period 2 to $p + 1$ are targeted in the second window. Move back one period and evaluate to the last window. After evaluating efficiency by window, it is possible to analyze the trend, stability, seasonal behavior of each DMU efficiency based on the result.

Window analysis can also be used even if the number of DMUs is small compared to the number of input and output elements. This is because, even if the number of DMUs is n, the number of DMUs to be evaluated in each window is increased to pn if the window width is determined as p.

$$p = \begin{cases} \frac{k+1}{2} & kisodd \\ \frac{k+1}{2} \pm \frac{1}{2} & kiseven \end{cases} \tag{1}$$

Table 1: Number of DEA-Window

Period / window	1 2 3 4 5 · · · · · · · · · · · k
1	1 · · · p
2	2 · · · $p+1$
3	3 · · · $p+2$
.	.
.	.
w	$k-p+1$ · · · k

If the number of DMUs is n, the characteristics of DEA-Window can be obtained as shown in Table 2.

Table 2: Characteristics of DEA-Window

Number of windows	$w = k - p + 1$
Number of DMUs for each Window	np
Total Number of DMUs	npw
Width of the Window	$p = \begin{cases} \frac{k+1}{2} & kisodd \\ \frac{k+1}{2} \pm \frac{1}{2} & kiseven \end{cases}$

3. EMPIRICAL ANALYSIS OF DEA-WINDOW

3.1 Determining DMU and Input/Output factors

DMU selected IT-Service companies with KRX (KoRea eXchange) listed business performance over 7 years[12]. As inputs, assets, liabilities, and capital are selected as sales factors, operating profit, and net profit. Correlations between the input and output factors were found to be sufficiently correlated.

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3.2 Analysis of DEA-Window

The characteristics of the DEA-Window are set to 7 DMUs (*n*), the analysis period (*k*) is 7 years from 2012 to 2018, and the window width (*p*) is 4 years. The number of windows (*w*) is 4 (= *k-p + 1*), the number of DMUs for each window is 28 (= *np*), and the number of DMUs is 112 (= *npw*).

The average efficiency by year and the average efficiency by each window are shown in Table 3 and Table 4. Each variability is shown in Figure 1 and Figure 2.

Table 3: Average Efficiency by Year

Window / DMU	12	13	14	15	16	17	18
D01	1	0.918	1	0.895	0.919	1	1
D02	1	0.965	0.806	0.862	0.949	0.992	1
D03	0.628	0.555	0.462	0.543	0.672	0.723	1
D04	0.520	0.421	0.564	1	0.888	0.968	0.774
D05	0.586	0.505	0.284	0.692	0.567	0.416	0.445
D06	1	1	1	0.753	0.667	0.638	0.280
D07	0.829	0.951	0.985	0.910	0.936	0.950	0.794

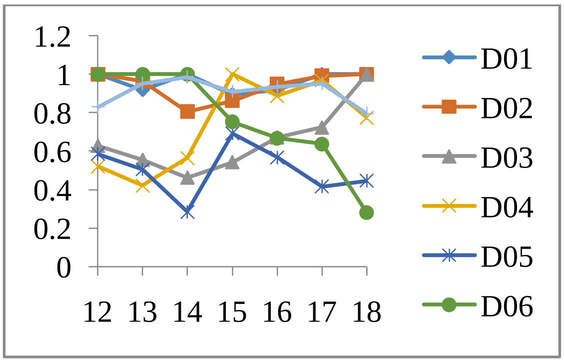

Figure 1: Average Efficiency Variation by Year

As shown in Figure 1, DMU D06 is downward trending, D03 is trending upward, D01 is only trending to maintain high efficiency, and it is difficult for other DMUs to keep track of trends.

Table 4: Average Efficiency through Window

Window / DMU	12-13-14-15	13-14-15-16	14-15-16-17	15-16-17-18
D01	0.940	0.937	0.944	0.971
D02	0.897	0.895	0.898	0.966
D03	0.511	0.545	0.624	0.760
D04	0.615	0.727	0.859	0.906
D05	0.494	0.504	0.474	0.578
D06	0.922	0.836	0.747	0.636
D07	0.885	0.929	0.948	0.945

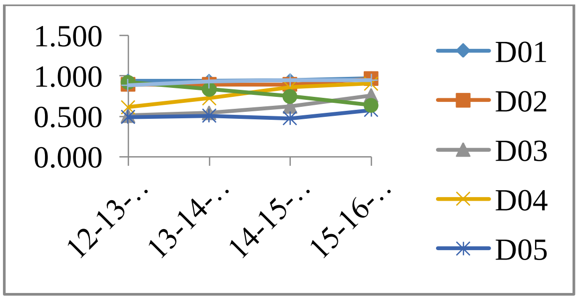

Figure2: Average Efficiency Variation through Window

In Figure 2, DMU D01, D02, and D07 are trending to maintain high efficiency, while D04 and D03 are trending upward. D06 is in a trend of declining efficiency, and D05 is transitioning to the upward trend in the last window.

The analysis of efficiency through the Window shows that it is easier to understand the trend than the annual efficiency analysis.DEA model is analyzed by DEA-Window model by applying CCR-I model.

Table 5-(a), (b) shows the results of DEA-Window analysis by IT-Service companies. The average in the table is the average per window. The overall average is the average of DMU windows. The ranking is determined from the DMU with the highest average efficiency to the lower DMU. The average annual average efficiency is the average of the year. It is the difference between the maximum value and the minimum value.

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Table 5-(a): Result of DEA-Window Analysis

Yr. DMU	12	13	14	15	16	17	18	Ave.
D01	1	0.892	1	0.869				0.940
		0.943	1	0.876	0.930			0.937
			1	0.876	0.901	1		0.944
				0.958	0.926	1	1	0.971
Yr. Ave.	1	0.918	1	0.895	0.919	1	1	
C-Ave.		0.052	0	0.089	0.029	0		
D02	1	0.962	0.796	0.831				0.897
		0.968	0.812	0.862	0.938			0.895
			0.809	0.861	0.938	0.983		0.898
				0.893	0.970	1	1	0.966
Yr. Ave.	1	0.965	0.806	0.862	0.949	0.992	1	
C-Ave.		0.005	0.016	0.062	0.032	0.017		
D03	0.628	0.527	0.392	0.496				0.511
		0.583	0.412	0.529	0.655			0.545
			0.582	0.542	0.656	0.714		0.624
				0.604	0.704	0.732	1	0.760
Yr. Ave.	0.628	0.555	0.462	0.543	0.672	0.723	1	
C-Ave.		0.057	0.191	0.108	0.049	0.018		
D04	0.520	0.397	0.543	1				0.615
		0.444	0.575	1	0.891			0.727
			0.575	1	0.891	0.970		0.859
				1	0.882	0.966	0.774	0.906
Yr. Ave.	0.520	0.421	0.564	1	0.888	0.968	0.774	
C-Ave.		0.047	0.031	0	0.009	0.004		
D05	0.586	0.487	0.278	0.623				0.494
		0.522	0.288	0.634	0.570			0.504
			0.287	0.626	0.566	0.416		0.474
				0.886	0.564	0.415	0.445	0.578
Yr. Ave.	0.586	0.505	0.284	0.692	0.567	0.416	0.445	
C-Ave.		0.035	0.010	0.263	0.006	0.001		

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D06	1	1	1	0.688				0.922
		1	1	0.735	0.609			0.836
			1	0.741	0.619	0.631		0.747
				0.847	0.774	0.644	0.280	0.636
Yr. Ave.	1	1	1	0.753	0.667	0.638	0.280	
C-Ave.		0	0	0.160	0.165	0.014		
D07	0.829	0.925	0.955	0.831				0.885
		0.977	1	0.882	0.856			0.929
			1	0.925	0.952	0.914		0.948
				1	1	0.987	0.794	0.945
Yr. Ave.	0.829	0.951	0.985	0.910	0.936	0.950	0.794	
C-Ave.		0.052	0.045	0.169	0.144	0.072		
T-Ave.	0.795	0.759	0.729	0.808	0.800	0.812	0.756	

Table 5-(b): Result of DEA-Window Analysis

	C-Ave.	RANK	SD	LDY	LPD
D01	0.948	1	0.053	0.089	0.131
D02	0.914	3	0.075	0.057	0.204
D03	0.610	6	0.144	0.141	0.608
D04	0.777	5	0.226	0.047	0.603
D05	0.512	7	0.158	0.257	0.608
D06	0.785	4	0.209	0.165	0.720
D07	0.927	2	0.069	0.124	0.206

The average efficiency over the seven years is D01-D07-D02-D06-D04-D03-D05.

The stability evaluation is possible by analyzing the values of SD (Standard Deviation), LDY (Largest Difference between scores in the same Year) and LPD (Largest Difference between scores overall period). Thus, the efficiency of seven IT service companies over the past seven years can be grasped.

In DMU D01, SD and LDP are relatively low and efficiency is relatively high, and it is shown that the efficiency of the company is maintained at the highest level for a long period of time. However, LDY is in third place, and efficiency is expected to decline slightly in 2015.

In DMU D04, SD was the highest, LYD was the lowest, but LPD was relatively high. This is attributed to the dramatic improvement in efficiency from 2013 to 2015, which is reflected in the increase in efficiency.

In DMU D06, SD was relatively high and LPD was the highest. This is highly efficient from 2012 to 2014, but the efficiency has fallen sharply until 2018.

The DMU D05 showed that the SD was moderately proportional to the other DMUs, but the LYD was the highest and the LPD was relatively high. This is reflected in the trend of increasing efficiencies in the last window while the efficiency is consistently low.

A comprehensive evaluation of the seven DMUs shows that the DMUs D01, D02, and D07, which are relatively high in efficiency and are continuously maintained and managed. DMUs with increasing efficiency are D03 and D04. The DMU, which is a declining trend in efficiency, is D06 and its efficiency is decreasing. There is no

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big change in efficiency, but DMU D05, whose efficiency has recently increased [14-16].

4. RESULTS

This study analyzed the efficiency of IT service companies through DEA-Window over 7 years. Stability was also analyzed through SD, LYD, and LPD which showed volatility.

The average efficiency over the seven years was in the order of D01-D07-D02-D06-D04-D03-D05. On the other hand, DMU, which needs to be aggressively improved in efficiency, has not been as efficient as it was in D05, but efficiency has increased recently.

In addition, a more innovative efficiency improvement plan should be derived and implemented with D06, which can jeopardize the survival of the company with the trend of decreasing efficiency. And DMU D04 and D03 should lead the efficiency trend to continue. On the other hand, DMU should monitor D01, D02, and D07 to see if the current efficiency is maintained in the future

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