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Measuring Relative Efficiency of Korean Construction Company using DEA/Window

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***Abstract*—**Sub-prime mortgage crisis which began in the US is regarded as the most economic crisis since the Great Depression in the early 20th century. Especially, hidden problems on efficient operation of a business were disclosed at a time and many financial institutions went bankrupt and filed for court receivership. The collapses of physical market lead to bankruptcy of manufacturing and construction businesses. This study is to analyze dynamic efficiency of construction businesses during the five years at the turn of the global financial crisis. By discovering the trend and stability of efficiency of a construction business, this study's objective is to improve management efficiency of a construction business in the ever-changing construction market. Variables were selected by analyzing corporate information on top 20 construction businesses in Korea and analyzed for static efficiency in 2008 and dynamic efficiency between 2006 and 2010. Unlike other studies, this study succeeded in deducing efficiency trend and stability of a construction business for five years by using the DEA/Window model. Using the analysis result, efficient and inefficient companies could be figured out. In addition, relative efficiency among DMU was measured by comparing the relationship between input and output variables of construction businesses. This study can be used as a literature to improve management efficiency for companies with low efficiency based on efficiency analysis of construction businesses.

***Keywords*—**Construction Company, DEA, DEA/Window, Efficiency Analysis

I. Introduction

THE financial cold wave of subprime crisis continued since the second half of 2007 is regarded as the biggest economic crisis in the global financial and physical market after the World Economic Depression in the early 20th century. Particularly when hidden ill practices and evils relating corporate management efficiency were revealed all at once, bankruptcies or court receiverships of global financial companies became a reality, and resultant collapse of the physical market led to default crisis of manufacturing and construction industries. The construction market in Korea remains in danger of this default crisis without overcoming it completely yet.

This situation made companies try to attain competitive advantage through management innovation, and also made enterprise efficiency essential.Korean construction companies must make every effort to establish efficient organizational system and to strengthen internal capability [1]. As efficiency of construction companies is becoming more important, a lot of research on efficiency of construction companies is being carried on. However, existing studies are focused mainly on static efficiency analysis (as of a certain time).

Thus, this study intends to analyze dynamic efficiency of Korean construction companies over the 5 years before and after the global financial crisis. Through this analysis, this study intends to identify efficiency trend and stability of Korean construction companies, and contribute to raising management efficiency of construction companies in the rapidly changing construction market.

This study performed an analysis with top 20 construction companies in the 2010 contract ranking. Data for analyzing efficiency of Korean construction companies was collected through kocoinfo [2], a website specializing in corporate information of companies in Korea. For analysis of static efficiency, data in 2008 was used; and for analysis of dynamic efficiency, data from 2006 to 2010 was used. This study used EnPAS [3], an efficiency and productivity analysis program, to analyze static efficiency; and used EnPAS and MS Excel to analyze dynamic efficiency.

The research flow is as follows:

1) Literature Review, DEA Modeling, DEA/Window Analysis Review

2) Selecting variables for efficiency evaluation of construction companies

3) Analyzing Relative Efficiency based on static and dynamic efficiency analysis

II. Theoretical Study

A. Previous Studies

TABLE I
Previous Study

Author	Year	Topics
Kim et. al [4]	2010	To analyze the efficiency of construction companies with comprehensive construction capability and identify causes if inefficiency
Lee et. al [5]	2010	To analyze the efficiency of construction companies for helping select a contractor company in carrying on a construction project
Kim et. al [6]	2008	To analyze the efficiency of apartment construction companies for helping apartment buyers choose an apartment wisely

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As shown in Table. I, there is lots of previous study on static efficiency evaluation at a certain time, but there is little research on dynamic efficiency evaluation reflecting many different situations. Thus, there is need for research on trend and stability of construction companies rather than efficiency analysis at a certain time.

B. DEA and DEA/Window Analysis

Data envelopment analysis (DEA) is measurement method based on linear programming. In general, this method derives empirical efficiency frontier using data relative to input and output factors of a target company with several standards applied to production possibility set [7]; it is also a nonparametric approach of measuring efficiency of a target company by comparing efficient frontier derived this way with a target company. Here, unit of a target company is called decision making unit (DMU); DMU is responsibility center which generates varied outputs using many inputs; and DMU includes company, hospital, school, court, military unit, labor union, bank, etc [8].

Most DEA analyses are handled on the basis of cross-sectional analysis which evaluates DMU efficiency, a static factor. However, the method of measuring efficiency on the basis of only inputs and outputs at a certain time has a weak point that it can't consider dynamic changes of efficiency according to changing circumstances and overuse of current resources for increasing future outputs. To supplement this weak point, DEA/Window analysis approach was developed.

DEA/Window approach considers trend, stability, and seasonal behavior; and it is also useful when the number of DMU is not enough compared to the number of inputs and outputs.

In general, when total period of data collected for DEA/Window analysis is k and window range is p, periods of windows are shown in Table 2. Thus, the number of windows is as follows; w=k-p+1.

TABLE II
WINDOW AND PERIOD FOR DEA/WINDOW ANALYSIS

Period / Window	1	2	3	.	.	.	.	.	.	.	K
1	1	.		P							
2		2				P+1					
3			3				P+2				
W=k-p+1								k-p+1			k

Here, when the number of DMU is n, window features are shown in Table III.

TABLE III
WINDOW AND DMU

Index	Contents
Number of Window	W = k – p + 1
Total Number of DMU for Each Window	Np
Total Number of DMU	npw
Growth of Total DMU	n(po1)(k-p)

Finally, an increase in the number of DMUs compared to static analysis means that the number of DMU used for Window analysis is larger than that of DMU used for static analysis.

III. SELECTING VARIABLES FOR EFFICIENCY ANALYSIS

A. Selection of Target Companies

For data analysis, all the data relating Financial Statement (F/S) and Income Statement (I/S) from 2006 to 2010 of top 20 Korean construction companies as of 2010 was collected. In the process of collecting data, companies, whose data is lost or which cannot be classified as a single type of business, were excluded.

For static efficiency analysis, data in 2008 was analyzed through input-centered BCC model (Banker, Charnes, and Cooper) [9]. And for dynamic efficiency analysis, data from 2006 to 2010 was analyzed through DEA/Window model.

B. Selection of Input and Output Variables

With regard to efficiency evaluation, selecting and measuring input and output factors properly is a key to determining the accuracy of DEA results. The selection of input and output factors can have a great effect on scores of derived efficiency. In case of DEA model, when the number of input and output factors increases, the number of DMU evaluated as efficient also increases, which makes it difficult to identify inefficient DMUs [10].

Thus, as this study aims at dynamic efficiency analysis, it referred to variables in Table 4 used frequently in existing DEA study in order to select appropriate variables.

TABLE III
SELECTING INPUT AND OUTPUT VARIABLES ON EXISTING STUDY

Author	Year	Input Variables	Output Variables
Kim et al. [4]	2010	- Fixed assets - Total labor cost - Material cost(cost of sales)	- sales - net profit during the term
Lee et al. [5]	2010	- Total labor cost - Selling and administrative expenses - Number of employees	- sales - net profit during the term
Kim et al. [6]	2008	- Number of employees - capital	- sales - net profit during the term
Kim, [11]	2005	- Number of employees - Management assets - Input expenditures	- sales - contracts outstanding - added value

Capital as input factor is the total amount of capital invested on a company. Gross assets are the total amount of assets, whereas capital is the total amount of debts and capital stock, and thus capital stock was selected as input factor for evaluating operation efficiency. And as construction is a labor

intensive industry, the number of employees was also selected as input factor.As input variables, the number of employees and capital stock were selected; and as output variables, sales and net profit during the term were selected as in Table 5.

TABLE V
SELECTION OF INPUT VARIABLES AND OUTPUT VARIABLES

Index	Input Variables	Output Variables
Static Efficiency Analysis	Number of employees	Sales
Dynamic Efficiency Analysis	Capital	Net profit during the term

Sales, an output factor, are a representative operation performance of a company; and it is most frequently used for efficiency analysis. Company is defined as a group seeking profit. Factors indicating profits of a company include pretax income, operating cash flow, etc., but net profit during the term and net income which subtracts expenses from profits coming from production activities of a company, show the results of all management activities of a company explicitly. Descriptive statistics of input and output factors is shown in Table 6.

TABLE VI
DESCRIPTIVE STATICS OF CONSTRUCTION COMPANIES (2008)

Index	Min.	Max.	Avg.	Standard Deviation
Sales (Million won)	669,874	7,271,096	2,184,300	2,035,950
Net profit during the term (Million won)	-32,972	381,553	66,556	1,193,540
Number of employees (person)	533	5,378	1,662	1432
Capital (Million won)	184,087	3,190,627	950,374	1,017,760

IV. EFFICIENCY ANALYSIS USING DEA/WINDOW

A. The results of Static Efficiency Analysis

According to the results of static efficiency analysis in Table 7, HYUNDAI DEVELOPMENT Corporation, KUMHO E&C, BYUCKSAN E&C, POONGLIM Corporation, and SAMHWAN Corporation turned out to belong to efficiency 1 group, and they were also excellent in scale efficiency. This means that those companies are doing efficient management in terms of scale, too. Meanwhile, there are some companies somewhat favorable in terms of scale in spite of inefficient management by and large.Most companies, whose scale profitability was found to be DRS, are large scale corporations including DAELIM E&C, GS E&C, DOOSAN E&C, HYUNDAI E&C, DAEWOO E&C, etc., which means that it is important to raise efficiency by reducing their scale.

TABLE VII
RESULT OF EFFICIENCY ANALYSIS OF CONSTRUCTION COMPANIES (2008)

Ranking	DMU	Efficiency			Reference frequency
		BCC	Efficiency of Scale	Income Scale	BCC
1	HYUNDAI DEVELOPMENT Corporation	1	1	CRS	3
1	KUMHO E&C	1	1	CRS	10
1	BYUCKSAN E&C	1	1	CRS	0
1	POONGLIM Corporation	1	1	CRS	0
1	SAMHAWN Corporation	1	1	CRS	4
2	SAMBU Corporation	.8547	.8547	IRS	6
3	TAEYOUNG E&C	.8123	.964	IRS	0
4	DAELIM E&C	.7423	.7423	DRS	2
5	DAEWOO E&C	.6562	1	DRS	0
6	GS E&C	.6518	.6518	DRS	1
7	DOOSAN E&C	.6434	.9862	DRS	0
10	HANSHIN E&C	.6114	.6936	IRS	0
11	KYERYONG Corporation	.5884	.7786	IRS	0
12	KEANGNAM Corporation	.57	.9366	IRS	0
13	SSANGYONG E&C	.5656	.8522	IRS	0
14	HYNDAI E&C	.5314	.736	DRS	0
15	HALLA E&C	.4481	.7467	IRS	0
16	KOLON E&C	.4072	.7078	IRS	0
	Avg.	.7248	.8529		
	Standard Deviation	.1963	.13158		
	Number of efficient DMU	5	5		
	Number of IRS			11	
	Number of DRS			4	
	Number of CRS			5	

Reference frequency means how often efficient construction companies in 2008 appeared as reference set of inefficient construction companies respectively. As shown in Table 7, efficient companies were in the following order; KUMHO

Industrial, SAMHAWN Corporation, HYUNDAI DEVELOPMENT Corporation, DAELIM E&C, and GS E&C; and their reference frequencies were 10, 6, 4, 3, 2, and1 respectively.

B. The results of Dynamic Efficiency Analysis

To examine efficiency trend of 20 construction companies over the 5 years, graphs in Figure 1 show yearly efficiency means.

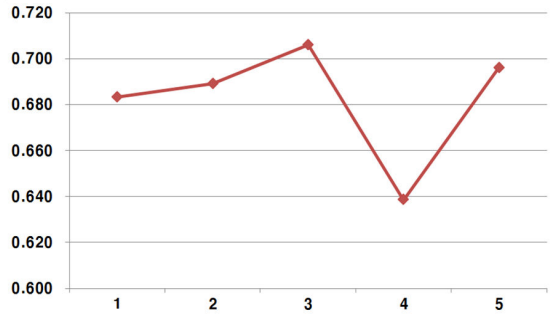

Fig. 1 Trend of mean efficiency of construction companies from 2006 to 2010 (5 years)

As shown in Figure 2, overall efficiency means increased between 2006 and 2008, but efficiency decreased from 2008 to 2009 due to aftermaths of the global financial crisis.

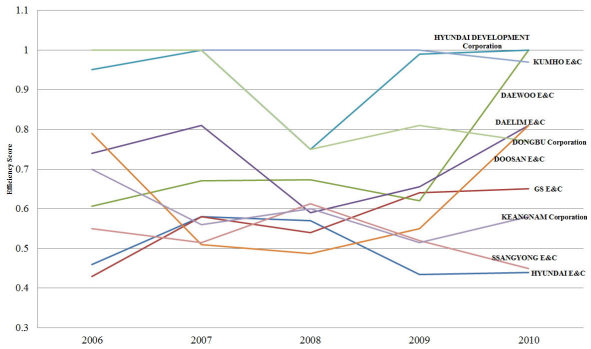

Fig. 2 Efficiency trend of top 10 construction companies

By measuring Standard deviation (SD), largest difference between scores in the same year (LDY), and Largest difference between scores the entire period (LDP) through dynamic efficiency analysis, this paper could identify the stability against efficiency of 20 Korean construction companies over the 5 years. As trend of 20 Korean construction companies in Table 8 show, different companies showed different trends. Window range was determined as 3 years; and the number of windows was determined as 3 because data was the result of business performance over the 5 years.

Among these construction companies, SD of KUMHO E&C was the smallest, which indicates that its efficiency of each window is the most stable, SD of BYUCKSAN E&C was the largest, which indicates that its efficiency of each window is the most unstable.

And LDY of KUMHO E&C was the lowest and its yearly efficiency was also the most stable, whereas LDY of DONGBU Corporation was the largest, which means that its yearly efficiency was the most unstable.Meanwhile, with regard to LDP, KUMHO E&C was the lowest or 0.03, which indicates that its change in efficiency over the recent 5 years was the smallest, whereas BYUCKSAN E&C was the largest or 0.640, which indicates that its change in efficiency over the recent 5 years was the largest.

TABLE VIII
RESULT OF DEA/WINDOW ANALYSIS

Index	Avg.	All Avg.	SD	LDY	LDP
DAELIM E&C	.75 .75 .75	.75	.06	.05	.18
HYUNDAI INDUSTIRAL Corporation	.98 .99 1.0	.99	.01	.02	.05
DOOSAN E&C	.64 .57 .67	.62	.11	.04	.32
KUMHO E&C	1.0 1.0 .99	.99	.01	.00	.03
BYUCKSAN E&C	.71 .65 .61	.65	.26	.07	.64
DONGBU Corporation	.88 .84 .82	.84	.12	.22	.36

V. CONCLUSION

This study analyzed static and dynamic efficiency of leading Korean construction companies using DEA/Window model. For this purpose, relevant data was collected from to 20 construction companies in Korea.

This study, designed to analyze dynamic efficiency, referred to variables used frequently in DEA study to select appropriate variables. Based on selected variables, this study analyzed static efficiency in 2008 and dynamic efficiency from 2006 to 2010.Unlike existing studies, this study could examine efficiency trend and stability of construction companies over the 5 years through DEA/Window model.

Based on the results of analysis, this paper could distinguish between efficient companies and inefficient companies. This study also measured relative efficiency between DMUs by comparing input variables and output variables of construction companies, and aimed at investigating possible causes of inefficiency with regard to inefficient DMUs.This author expects that managers of construction companies could improve corporate management efficiency by making good use of the results of this study in the future.

If future research diversifies the category of target companies for efficiency analysis, it can generate significant findings, this author believes. Meanwhile, BCC model is considered to have a limitation in analyzing possible causes of inefficient DMUs since the model is confined to technical efficiency aspects. To supplement this limitation, there is need to analyze scale efficiency as well as technical efficiency through CCR model.

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