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Full length research paper

The characteristics of changes in construction companies to become insolvent by size following macroeconomic fluctuations

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In the present study, individual groups of construction companies were first classified according to size, and then the processes of changes needed for them to become insolvent were examined utilizing KMV models. Another objective of the present study was to analyze the relationship between macroeconomic fluctuations and the changes needed for construction companies to become insolvent (based on their size). In the present study, construction companies were classified by size, and the relationship between the changes required for insolvency of construction companies and macroeconomic fluctuations was analyzed. To analyze the relationship, vector error correction models (VECMs) were constructed. Through the analysis, as perceived intuitively, large companies were determined to be financially sounder than small and medium sized companies. In the case of small and medium sized companies, the trend of changes needed to become insolvent was extremely insensitive to economic fluctuations. That is, it was identified that in the case of relatively small companies, poor financial environments were constantly maintained. Large companies were generally more financially stable, but they responded very sensitively to business. Consequently, their financial conditions deteriorated more rapidly than small or medium sized companies when rapid economic fluctuations occurred.

Keywords: Insolvency, Macroeconomic fluctuations, Construction company, KMV, VECM

NTRODUCTION

The damage caused by the U.S. financial crisis of 2008 that spread to the rest of the world affected not only the financial markets, but also the real economy (Hellwig, 2009; Hegedus et al., 2011), and caused a recession in the housing market (Mishkin, 2011). Consequently, the management environments of construction companies gradually deteriorated, accelerating construction companies' insolvency. The deterioration of construction companies resulting from the deterioration of the construction business as a whole is not just a problem of construction companies only. That is, since not only construction companies but also other diverse market participants such as public institutions, financial institutions, and households are jointly involved in the construction industry, the deterioration of construction companies can cause serious economic loss. From this viewpoint, examining the relationship between macroeconomic fluctuations and insolvency in construction companies is considered an important issue. Since the internal/external business capabilities of construction companies vary depending on the companies' size, their situations of insolvency resulting from macroeconomic fluctuations are also judged to vary according to size.

In a review of the literature in the areas of finance and the economy, in the past, literature simply related to corporate failure predictions conducted through logistic regression, Z-score, and survival analysis models existed. Currently, however, many studies related to KMV models

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Table 1. Trend of changes in major construction indexes during macroeconomic fluctuations

Index	Unit	Time point				
		2006	2007	2008	2009	2010
Amount of construction work contracts	(100 million KRW)	1,073,184	1,279,118	1,200,851	1,187,142	1,032,298
Area of building permission	1,000㎡	133,271	150,957	120,658	105,137	125,447
Unsold apartments	Unit	73,772	112,254	165,599	123,297	88,706
Bankrupt companies	Piece	106	120	130	87	86

Source : Construction Association of Korea

that enable sensitive measurement of the degree of changes needed to become insolvent over time are being conducted. On the other hand, despite the fact that insolvency in general is a very critical issue, studies related to the construction industry in particular are quite insufficient. Those that have been conducted are mostly qualitative and studies related to the prediction of construction companies' bankruptcy focused on judging whether construction companies had gone bankrupt.

Therefore, in the present study, individual groups of construction companies were first classified according to size, and then the processes of changes needed for them to become insolvent were examined utilizing KMV models. Another objective of the present study was to analyze the relationship between macroeconomic fluctuations and the changes needed for construction companies to become insolvent(based on their size).

As mentioned above, in the present study, construction companies were classified by size, and the relationship between the changes required for insolvency of construction companies and macroeconomic fluctuations was analyzed. To analyze the relationship, vector error correction model(VECM) were constructed. One model was developed to analyze the relationship between macroeconomic variables and the degree of changes required for 10 highly ranked companies to become insolvent was defined as a Dh_t model; a second model was created to analyze the relationship between macroeconomic variables and the degree of changes needed for 10 low ranking companies to become insolvent was defined as a Dl_t model. In the present study, the amount of construction investments, the composite stock price index, and interest rates were utilized as macroeconomic variables.

Trend of changes in the construction business following macroeconomic fluctuations in Korea

The macro-economy changes from moment to moment and affects the domestic construction business in Korea. Furthermore, serious macroeconomic fluctuations can have a major effect on the construction business, leading construction companies to become insolvent. The trend of changes in major construction indexes during the subprime financial crisis, based on the statistical data of the Construction Association of Korea, is shown in Table 1. From this table, it is clear that major construction indexes deteriorated during the subprime financial crisis. This phenomenon was most likely caused by the occurrence of a long-term recession of real business, which was a result of macroeconomic impacts. That is, the construction business, which is considerably affected by domestic business, also recessed because of the decreased demand for houses and the deterioration of construction investor sentiment. Since this rapid deterioration of the construction business is eventually connected to construction companies' insolvency, macroeconomic fluctuations are also thought to be closely related to their insolvency. In addition, since sales abilities and business structures vary according to the size of construction companies' size, the situations of changes to become insolvent of construction companies resulting from macroeconomic fluctuations are also judged to be different according to their size. Therefore, in the present study, construction companies were classified by size to analyze the relationships between macroeconomic fluctuations and changes required for construction companies to become insolvent, as they varied according to the companies' size.

Literature review

Existing studies related to insolvency in construction companies have focused mostly on construction industry failures and the bankruptcy of construction companies or construction projects.

Kangari (1988) stressed that construction companies should recognize the possibility of business failure and the importance of consistently monitoring their financial status using the financial ratio. Kangari et al. (1992) presented a quantitative model using financial ratios, namely the current ratio, total liabilities to net worth, total assets to revenues, revenues to net working capital, return on total assets, and return on net worth.

The authors developed a model using multiple linear regression to assess the financial performance and grade of construction companies. Six groups, including general contractors, operative builders, and heavy construction workers, were the targets of the model. Russell and Casey (1992) presented an analytical overview of the bankruptcy code and laid out the factors that can be used by debtors and creditors when deciding whether to file for bankruptcy. Langford et al. (1993) examined the usefulness of ratio analysis and used the Z model to judge whether a company was headed toward insolvency. Loosemore and Teo (2000) investigated the risk management practices of construction companies by using a diagnostic model of crisis preparedness. The authors concluded that many construction companies have an inadequate understanding of their crisis exposure. Koksal and Arditi (2004) developed a model that can be employed by a user to examine the condition of a company. Sueyoshi and Goto (2009) described a practical use of the DEA-DA approach for bankruptcy-based performance assessment. Through multivariate regression analysis, Lowe and Moroke (2010) diagnosed the reasons for insolvency in the construction industry in the United Kingdom. Tserng et al. (2011b) proposed a support vector machine-based model as a method to predict bankruptcy in construction firms, and by comparing their model with existing logistic regression models, they demonstrated its effectiveness. Al-Joburi et al. (2012) examined negative cash flow trends, patterns of construction performance, and their impact on construction company bankruptcy; they found that the amount, duration, and distribution of negative cash flow are critical contributing factors .

However, these previous studies have several weaknesses. First, it is difficult to get information in a timely manner because variables are only available periodically for analysis (Hillegeist et al., 2004). Second, the models were constructed by comparing defaulted and non-defaulted firms to determine the variables that differ between them (Gharghori et al., 2006). Third, the analysis parameters sometimes require periodic adjustments to take economic changes into account (Russell and Zhai, 1996). Fourth, it is possible for management to manipulate accounting numbers (Agarwal and Taffer, 2008).

Due to the emergence of innovative debt securities products and credit derivatives of corporations, academia and workers in the industry have become interested in models based on approaches related to corporate bankruptcy prediction. One of these models is the option-based model, which was devised by Black and Scholes (1973) and Merton (1974) (Bharath and Shumway, 2008). An option-based model uses corporate stock information that reflects qualitative, quantitative, internal, and external information about a corporation. An option-based model can be used for bankruptcy prediction of construction companies (Tserng et al., 2011a). Tserng et al. (2011a) estimated the bankruptcy probability of construction companies in the U.S. using three kinds of option-based credit models, and they demonstrated that an option-based credit model was a good alternative model for bankruptcy prediction of construction companies.

Since the construction industry is closely tied to macroeconomic fluctuations, the degrees of changes required for construction companies to become insolvent before and after macroeconomic fluctuations should be grasped, and methods to quantitatively identify the degrees of recovery from such changes after certain events are considered necessary. Form this viewpoint, the present study is intended to analyze the relationship between macroeconomic fluctuations and changes needed for construction companies' insolvency utilizing KMV models.

KMV model

Merton's corporate bankruptcy prediction model is a structural approach model in which the Black-Sholes option pricing model is used to measure credit risk and to develop a theoretical credit risk measurement model because it tackles the concept of bankruptcy in a probabilistic manner. In the Merton model, the basic hypothesis is that insolvency occurs when the market value of corporate assets decreases to less than the debt value, and corporate stock values are regarded as a call option. This call option considers the corporate asset value the underlying asset, and the debt value that has to be repaid by the company is considered the exercise price. The KMV model was developed by the KMV Company in the late 1980s. It is based on Merton's model and uses market information. The KMV model, which uses Black-Sholes' option price model and the Merton model as the option price model, predicts that default or bankruptcy will occur when the corporate asset value drops below the default point (Lee, 2011). However, it is hard to reflect current information using models that are based solely on existing financial statements, because the reporting period for financial information is not consecutive. However, stock information, which is updated regularly, can be used in the KMV model to monitor a drop in the corporate asset value to less than the debt value. It therefore enables a company's degree of insolvency to be monitored in a timely basis. In addition, according to the option price model theory, because market prediction of future risk is reflected in the stock price, the corporate bankruptcy probability can be calculated more accurately because the expected value of the future risk has been separated and extracted from the stock price (Zhang et al., 2010).

Several researchers have empirically analyzed the precision of the KMV model. Kurbat et al (2002) examined the KMV model by level verification and analysis of calibration using three years of data from one

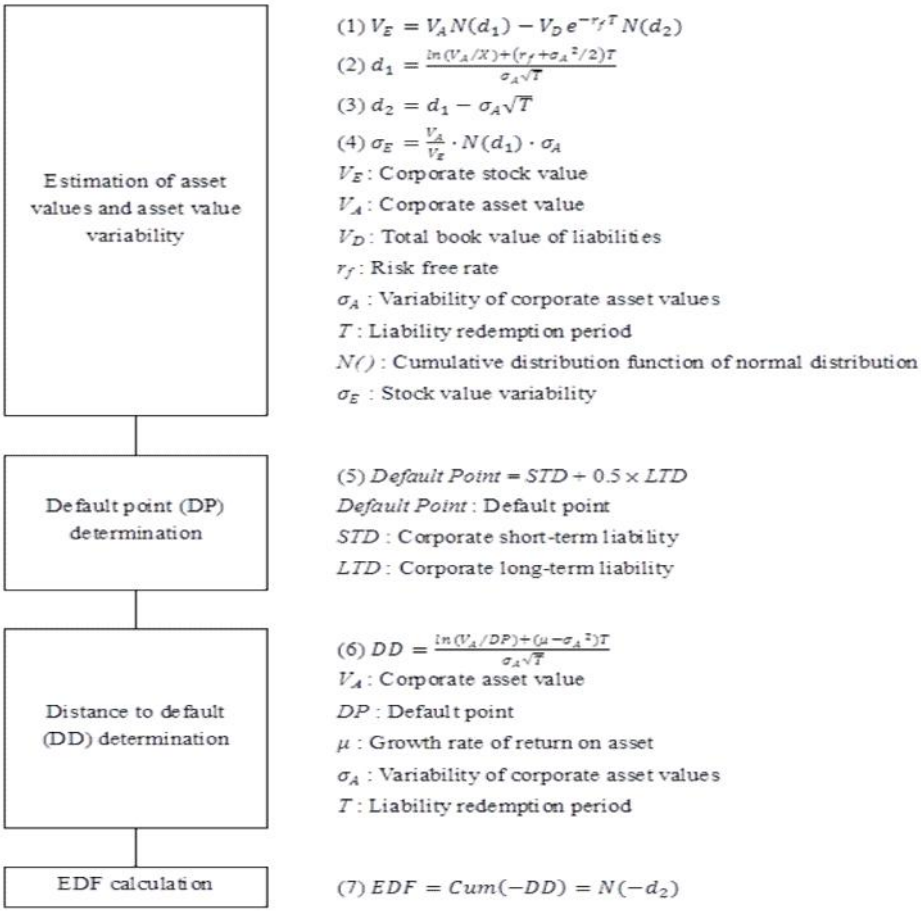


Figure 1. EDF calculation process

thousand U.S. companies and showed that the KMV model was quite useful. Crosbie et al (2003) picked financial firms as samples to check the KMV model and verified that it is an effective method for estimating the risk of default. Korablev et al (2007) regarded the KMV model as a useful way to evaluate credit risk by verifying the ability of KMV credit measures to discriminate non-defaulters from defaulters in North America, Europe, and Asia. The “New Basel Capital Accord” (2004) encouraged an Internal Ratings-Based (IRB) approach in credit risk management, as well as KMV. The KMV model is widely accepted and used globally (Chen et al, 2010).

Accordingly, the expected default frequency (EDF) drawn through the KMV model can sensitively measure the degree of changes required for firms to become insolvent by time point, and if the analysis periods are accumulated, the EDF can be converted into a time series variable to examine the process of these changes. Therefore, in the present study, the degrees of changes needed for construction companies to become insolvent were calculated and defined as EDFs, and EDFs were used as an analysis variable.

Calculation of the degrees of changes required for construction companies’ insolvency utilizing the KMV model

In the present study, EDFs were calculated utilizing the KMV model and the EDFs were utilized as a proxy variable indicating construction companies’ changes needed to become insolvent. To calculate the EDFs, in the present study, 20 construction companies with available quarterly financial data for the analysis period (from the 1st quarter of 2001 to the 4th quarter of 2010) were selected as samples among the currently listed construction companies in Korea. Of the selected 20 companies, 10 highly ranked companies based on size were classified into a Dh_t group, and 10 low ranked companies were classified into a Dl_t group. The Dh_t and Dl_t groups were separately applied to the KMV model based on their financial data and data from the Statistics of Korea to calculate their EDFs, as shown in the following Figure 1. The average values of the EDFs drawn as such were utilized as a variable indicating construction companies’ changes that were required to

Table 2. Results of EDF calculation by group

Time point(quarter)	EDF		Time point(quarter)	EDF	
	Dh_t group	Dl_t group		Dh_t group	Dl_t group
2001/01	0.9616	0.9662	2006/01	0.5487	0.8134
2001/02	0.9257	0.9517	2006/02	0.5985	0.8450
2001/03	0.9401	0.9543	2006/03	0.5434	0.8378
2001/04	0.9110	0.9252	2006/04	0.4991	0.8083
2002/01	0.8877	0.8949	2007/01	0.4864	0.8371
2002/02	0.9117	0.9271	2007/02	0.3536	0.7514
2002/03	0.9121	0.9203	2007/03	0.3201	0.7531
2002/04	0.9024	0.9148	2007/04	0.3653	0.8016
2003/01	0.9015	0.9338	2008/01	0.4783	0.8427
2003/02	0.8581	0.9208	2008/02	0.5713	0.8129
2003/03	0.8351	0.9258	2008/03	0.6737	0.9164
2003/04	0.7871	0.9100	2008/04	0.7818	0.9329
2004/01	0.8070	0.9192	2009/01	0.8149	0.9418
2004/02	0.8196	0.9272	2009/02	0.7861	0.9268
2004/03	0.7570	0.9196	2009/03	0.7572	0.9240
2004/04	0.7182	0.8756	2009/04	0.7086	0.9212
2005/01	0.7203	0.8789	2010/01	0.7126	0.9336
2005/02	0.6683	0.8471	2010/02	0.7585	0.9427
2005/03	0.6031	0.8125	2010/03	0.7121	0.9390
2005/04	0.5271	0.7846	2010/04	0.6726	0.9460

become insolvent. To measure EDFs, diverse variables are necessary. That is, variables such as asset value variability, asset values, default points, risk free rates, and the average values of returns on assets are necessary. In the present study, three-year maturity government bond interest rates were utilized as risk free rates, and returns on total assets among financial ratios were used as the average value for returns of assets. Asset value variability, asset values and default points were calculated through calculation formulas. The construction companies' EDFs at individual time points calculated as such were averaged to identify the trends, according to individual groups, of construction companies' changes leading to insolvency, as shown in Table 2. The trends were utilized as a variable indicating construction companies' changes needed to become insolvent based on group.

EMPIRICAL PROCEDURES

Selection of variables

To concretely identify the relationships between macroeconomic fluctuations and the changes leading to Korean construction companies' insolvency according to the size of construction companies, first, the EDFs of individual groups were defined as a variable indicating construction companies' changes required to become insolvent. In addition, since changes in the construction business may affect construction companies and lead to their insolvency, the amount of construction investments was defined as a proxy variable indicating the entire construction business. There are diverse indexes indicating the entire national economy, such as GDP and the composite stock price index. Recently, as global markets have gradually become larger, the ripple effects of changes in international markets have become substantial. Considering that securities markets sensitively react to these international markets changes, in the present study, the composite stock price index of Korea was defined as a variable indicating overall changes in markets. Interests have important effects on both suppliers and demanders in the construction industry. That is, since interest rates act as lending rates for project funds to suppliers and lending rates for house buying act as funds to demanders, interest rate changes are closely tied to the construction business. Since lending rates are generally interlocked with CD rates, in the present study, CD rates were utilized as an analysis variable that represents rate variables. The series data in the present paper are quarterly data from 2001 to 2010 (See table 3).

Table 3. Variables and descriptions

Series	Descriptions	Period	Frequency
Dh_t	EDF(average from high ranked 10 companies)	2001:1-2010:4	Quarterly
Dl_t	EDF(average from low ranked 10 companies)	2001:1-2010:4	Quarterly
Ci_t	Amount of construction investments	2001:1-2010:4	Quarterly
$KOSPI_t$	Composite stock price index	2001:1-2010:4	Quarterly
I_t	Interest	2001:1-2010:4	Quarterly

Table 4. Tests for unit roots (Augmented Dickey-Fuller tests)

Variables	Level		1st differencing	
	t-statistic	p-value	t-statistic	p-value
Dh_t	-2.263313	0.4428	-3.349892	0.0737
Dl_t	-1.553055	0.7931	-6.635065	0.0000
Ci_t	-2.689908	0.2461	-6.558229	0.0000
$KOSPI_t$	-2.732253	0.2302	-5.560683	0.0003
I_t	-1.713637	0.7261	-4.648326	0.0033

- Paraphrase indicates the signification number of lags chosen based on SIC (Schwartz Information Criteria)

Unit root test

To conduct a series analysis, the stability of series data should be secured. If a series analysis is conducted utilizing unstable series data, a spurious regression phenomenon results in which variables appear to be correlated with each other when they are really unrelated.

To test whether series data are stable, the existence of unit roots should be checked. If they exist, the series data are unstable. Therefore, in the present study, the ADF (Augmented Dickey-Fuller) test method, which is a representative unit root test, was utilized.

First, ADF unit root tests were conducted on individual level variables. According to the results, the null hypothesis that all the variables have unit roots could not be rejected at an appropriate significance level. However, when the level variables were subjected to the 1st differencing and ADF unit root tests were conducted thereafter, the null hypothesis that all of the variables have unit roots was rejected at an appropriate significance level (See table 4).

Cointegration test

Even if individual variables that have been introduced for analysis are unstable, linear combinations of the variables may have stable characteristics. That is, if difference variables for data are used, crucial information on long-term relationships between variables may be lost. Therefore, if variables are judged not to have such cointegration relationships, the Vector Auto Regression Model (VARM) is desirable to use, and if variables have cointegration relationships, the Vector Error Correction Model (VECM) is desirable.

Methods to judge the existence of cointegration include the ADF test and the Johansen Procedure. Gonzalo (1994) reviewed many methods to estimate cointegration vectors and empirically proved that the Johansen Procedure using the maximum likelihood estimation was superior to other test methods (Gonzalo, 1994).

Therefore, in the present study, the Johansen Procedure was utilized to conduct cointegration tests. According to Boswojk (1996), whereas the null hypothesis that there is no cointegration tends to be rejected when time lags are too short the power of the test will be weakened if time lags are set to be too long. Therefore, in the present study, lag order selection criteria based on SIC were utilized to set the appropriate lag order to 0 (See Table 5).

Cointegration tests were conducted through the Johansen Procedure. As a result, the null hypothesis that there is no cointegration could be rejected at a significance level of 5%, and it was indicated that at least two cointegrations existed. Therefore, in the present study, analyses were conducted utilizing the VECM (See Table 6).

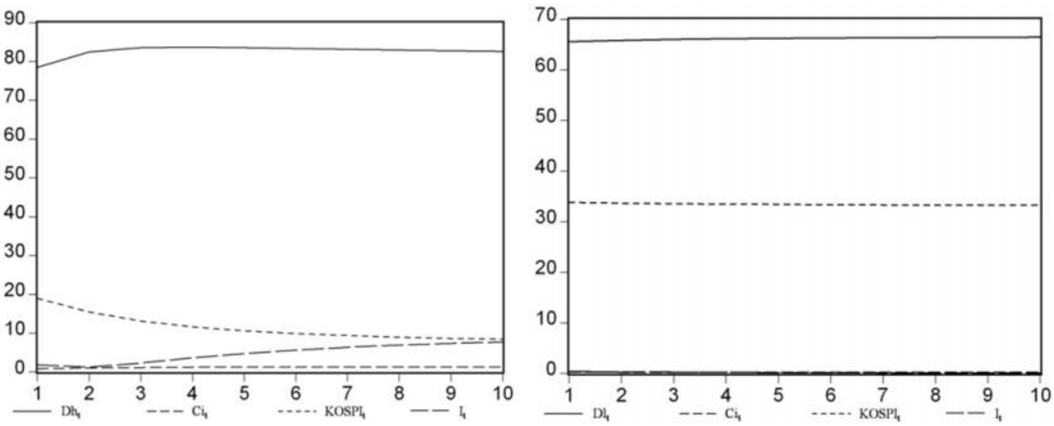
Table 5. Lag specification results for cointegration tests

Model	SIC (Schwartz Information Criteria)			
	Lag 0	Lag 1	Lag 2	Lag 3
Dh_t Model	-9.380015*	-8.741464	-7.728118	-6.551850
Dl_t Model	-11.29424*	-10.56942	-9.583152	-8.356912

Table 6. Cointegration test results

Model	Null hypothesis	Test statistic	0.05 Critical Value	p-value
Dh_t Model	r = 0*	79.95515	63.87610	0.0013
	r ≤ 1*	45.16799	42.91525	0.0292
	r ≤ 2	16.68706	25.87211	0.4386
	r ≤ 3	3.644709	12.51798	0.7927
Dl_t Model	r = 0*	77.97895	63.87610	0.0021
	r ≤ 1*	43.99765	42.91525	0.0388
	r ≤ 2	18.22281	25.87211	0.3292
	r ≤ 3	5.767390	12.51798	0.4904

- Significant at 5% level; - r is cointegration rank



(a) Variance decomposition of Dh_t (b) Variance decomposition of Dl_t

Figure 2. Variance decomposition graph

EMPIRICAL RESULTS

Results of variance decomposition analysis

The VECM is a method that can relieve some, although not all, problems of the VARM, and it is related to the concept of cointegration (Eagle and Granger, 1987). Most economic variables are unstable time series. If these unstable time series have cointegration relationships, series variables will have long-run equilibrium relations with each other, and it will become possible to test dynamic structural relationships using the VECM.

First, variance decomposition analysis was conducted in the present study by decomposing the prediction error variance of a variable in the model into prediction errors by variable and analyzing the degree to which the prediction error variance is explained by the variable itself and other variables. Through the variance decomposition analysis, the relative levels of contribution to the fluctuations of all variables were then measured.

Next, the individual variables' level of influence on EDF changes in the Dh_t model was reviewed, as shown in Figure 2, Table 7. It was indicated that EDFs had the highest level of explanatory power for EDF changes. That is, whereas EDFs showed a level of explanatory power of approximately 78.51% at the beginning, the level of explanatory power changed over time in a certain range to become approximately 82.65% in the final 10th quarter.

Table 7. Variance decomposition

Period	Variance Decomposition of Dh_t				Variance Decomposition of Dl_t			
	Dh_t	Ci_t	$KOSPI_t$	I_t	Dl_t	Ci_t	$KOSPI_t$	I_t
1	78.51926	0.796995	18.92294	1.760803	65.57356	0.253494	33.81165	0.361289
2	82.47653	0.991964	15.36295	1.168556	65.83881	0.240553	33.65509	0.265544
3	83.56593	1.103999	13.06719	2.262879	66.02284	0.231407	33.53861	0.207150
4	83.72107	1.172076	11.56519	3.541663	66.15476	0.224770	33.45130	0.169168
5	83.58202	1.216068	10.54407	4.657844	66.25201	0.219836	33.38507	0.143082
6	83.36673	1.246051	9.822675	5.564546	66.32549	0.216389	33.33408	0.124340
7	83.14986	1.267405	9.295480	6.287258	66.38223	0.213185	33.29422	0.110364
8	82.95503	1.283173	8.898858	6.862940	66.42691	0.210892	33.26258	0.099617
9	82.78732	1.295173	8.592941	7.324570	66.46274	0.209051	33.23707	0.091140
10	82.64527	1.304537	8.351840	7.698349	66.49194	0.207549	33.21621	0.084306

The composite stock price index showed a level of explanatory power of approximately 18.92% for EDF changes at the beginning, but the level of explanatory power decreased over time to become approximately 8.35% in the final 10th quarter. However, whereas interest rates showed a level of explanatory power for EDF changes of approximately 1.76% at the beginning, the level of explanatory power increased over time to become approximately 7.70% in the 10th quarter. The amount of construction investments that represents the construction business showed very low levels of explanatory power for EDF changes.

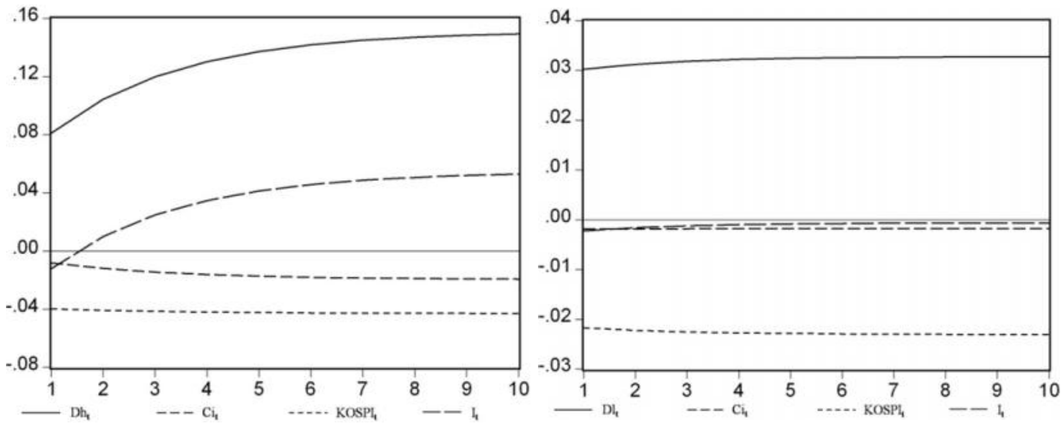
The individual variables' influence on EDF changes in the Dl_t model, are shown in Figure 2, Table 7. As with in the Dh_t model, it was indicated that EDFs had the highest level of explanatory power for EDF changes in the Dl_t model as well. That is, EDFs showed a level of explanatory power of approximately 65.57% at the beginning and maintained similar levels over time. The composite stock price index showed a level of explanatory power of approximately 33.81% for EDF changes at the beginning and maintained similar levels over time. However, the amount of construction investments and interest rates exhibited quite low levels of explanatory power for EDF changes.

Through the variance decomposition analysis, it could be identified that EDFs had the largest effects on EDF changes in both the Dh_t group and the Dl_t group and that these effects were maintained over time. This means that as a construction company changes and becomes insolvent, it becomes more difficult for that company to recover its original state. In addition, in both the Dh_t group and the Dl_t group, the composite stock price index's effect on EDFs was larger than that of the amount of construction investments. This means that the overall economic recession directly (and seriously) affected construction companies' changes leading to their insolvency. The reason this effect is lower than expected is the fact that even when private markets are depressed due to a macroeconomic recession, public works ordered by the government may maintain a certain level, or even increase. That is, since public works are continuously ordered, overall changes in construction investments become small. In the case of the Dh_t group, interest rates also affected construction companies' changes leading to their insolvency, to some extent. This is believed to be due to the fact that since construction companies included in the Dh_t group implement larger projects in relatively larger numbers than the Dl_t group, their EDFs sensitively react to changes in interest rates.

Results of impulse response analysis

Impulse response analysis was conducted to analyze mutual relationships between variables and ripple effects by identifying fluctuations in a variable in the model and other variables for a certain time when an impulse of 1 standard deviation has been applied to the variable. In the present study, the dynamics of EDFs were analyzed through impulse response analysis when a certain impulse had been applied to individual variables such as the amount of construction investments, the composite stock price index, and interest rates.

First, the results of impulse response analysis of the Dh_t model are shown in Figure 3, Table 8. EDFs showed fluctuations in a range of approximately 0.081% in response to their own impulse in the first quarter and the range of fluctuations increased over time to become approximately 0.149% in the final 10^{th} quarter. EDFs showed fluctuations in a range of approximately -0.008% in response to an impulse by the amount of construction investments in the beginning, but the range increased over time to become approximately -0.019% in the 10^{th} quarter. EDFs showed fluctuations in a range of approximately -0.040% in response to an impulse by the



(a) Response of Dh_t (b) Response of Dl_t

Figure 3. Impulse response graph

Table 8. Impulse response

Period	Response of Dh_t				Response of Dl_t			
	Dh_t	Ci_t	$KOSPI_t$	I_t	Dl_t	Ci_t	$KOSPI_t$	I_t
1	0.081083	-0.008169	-0.039805	-0.012142	0.030235	-0.001880	-0.021711	-0.002244
2	0.104323	-0.011968	-0.040834	0.009996	0.031238	-0.001836	-0.022243	-0.001608
3	0.119850	-0.014506	-0.041522	0.024786	0.031849	-0.001810	-0.022567	-0.001221
4	0.130224	-0.016202	-0.041982	0.034668	0.032222	-0.001793	-0.022764	-0.000985
5	0.137155	-0.017335	-0.042289	0.041270	0.032449	-0.001783	-0.022885	-0.000841
6	0.141785	-0.018092	-0.042494	0.045680	0.032587	-0.001777	-0.022958	-0.000753
7	0.144879	-0.018598	-0.042631	0.048627	0.032671	-0.001774	-0.023003	-0.000700
8	0.146946	-0.018936	-0.042723	0.050596	0.032722	-0.001771	-0.023030	-0.000667
9	0.148327	-0.019161	-0.042784	0.051911	0.032754	-0.001770	-0.023046	-0.000647
10	0.149249	-0.019312	-0.042825	0.052790	0.032773	-0.001769	-0.023056	-0.000635

composite stock price index in the beginning, but the range increased over time to become approximately -0.043% in the 10th quarter. EDFs showed fluctuations in a range of approximately --0.012% in response to an impulse by interest rates at the beginning, but the range of fluctuation became positive (+) over time to become approximately 0.052% in the 10th quarter. Next, the results of impulse response analysis of the Dl_t model are shown in Figure 3 and Table 8. EDFs showed fluctuations in a range of approximately 0.030% in response to their own impulse in the first quarter and the range of fluctuations increased over time to become approximately 0.033% in the final 10th quarter. EDFs showed fluctuations in a range of approximately -0.022% in response to an impulse by the composite stock price index in the beginning, but the range increased over time to become approximately -0.023% in the 10th quarter. However, it was indicated that the ranges of fluctuations of EDFs were small in response to impulses by interest rates and the amount of construction investments.

The results of the impulse response analysis indicated that EDFs were affected more by impulses by themselves in both the Dh_t group and the Dl_t group and that the effect increased over time. This eventually means that once construction companies' management conditions have deteriorated, it takes a considerable amount of time for them to recover. It was also indicated both the Dh_t group and the Dl_t group were greatly affected by impulses by the composite stock price index. This means that overall market conditions greatly affect construction companies' management conditions over time. On the other hand, on comparison between the Dh_t group and the Dl_t group, it can be seen that the Dh_t group was affected more by the composite stock price index impulses and that the Dl_t group showed much smaller ranges of fluctuations of EDFs in response to interest rate impulses or the amount of construction investments impulses compared to the Dh_t group. That is, it was indicated that larger companies were affected more by diverse variables such as overall market conditions, construction business, and interest rates. Companies in the Dl_t group are relatively smaller in size and their management conditions are generally not as well maintained as companies in the Dh_t. This phenomenon can be identified in Table 2 as well. That is, Table 2 shows that in the case of the Dl_t group, EDFs are relatively high. For this reason, most studies on the management conditions of construction companies generally focus the changes in small or medium sized construction companies that lead to insolvency. However, as identified in the present study, the management conditions of the Dh_t group are better than those of the Dl_t group; the Dh_t group responds more sensitively to macroeconomic fluctuations that the Dl_t group. That is, the Dh_t group companies are affected more by the impulses of sudden macroeconomic changes than the Dl_t group companies. In summary, although the more highly deteriorated management conditions of the Dl_t group companies are a problem, the more sensitive responses of the large sized Dh_t group companies to economic fluctuations compared to Dl_t group companies are also a major problem (See Figure 3 and Table 8).

CONCLUSION

Recently, since the subprime mortgage crisis, the Korean construction business has been stagnant, and there has been no sign of recovery. Consequently, Korean construction companies' management conditions have been extremely poor. Since construction project costs are high, money is generally borrowed from external sources, and various kinds of stakeholders are often involved in construction projects. That is, the insolvency of construction companies has significant adverse effects not only on construction companies but also on other stakeholders. From this viewpoint it is crucial to measure the degree of change needed for a construction company to become insolvent. In this respect, the objectives of the present study are twofold: first, to draw the processes of changes required for individual groups (classified based on the sizes of construction companies) utilizing the KMV model; and second, to analyze the relationships between macroeconomic fluctuations and construction companies' changes leading to insolvency based on the companies' size, through the vector error correction model (VECM) utilizing the processes of these changes within individual groups.

Through the analysis, as perceived intuitively, large companies were determined to be financially sounder than small and medium sized companies. In the case of small and medium sized companies, the trend of changes needed to become insolvent was extremely insensitive to economic fluctuations. That is, it was identified that in the case of relatively small companies, poor financial environments were constantly maintained. Large companies were generally more financially stable, but they responded very sensitively to business. Consequently, their financial conditions deteriorated more rapidly than small or medium sized companies when rapid economic fluctuations occurred.

Since project orders are concentrated in large companies due to the current structure of the construction industry, small or medium sized companies' financial conditions cannot typically be recovered through normal sales activities. Therefore, such companies should improve their financial structures by securing specialized technical skills. The high sensitivity of large companies to the business can be attributed to their concentrated business portfolios. Therefore, large companies should disperse their business portfolios so that they can secure stable profits even when construction business fluctuates.

In the present study, although the characteristics of construction companies' changes leading to insolvency were analyzed according to company size, there is a limitation in that solutions for related problems were roughly mentioned. Therefore, solutions to this problem should be analyzed from a practical viewpoint through questionnaire surveys and expert interviews, for instance.

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