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An analysis on the characteristics of Financial condition change of Korean construction companies: Using KMV model

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Using the KMV model, which was developed based on the Black-Scholes option pricing theory, we calculated expected default frequencies (EDFs) of construction companies and compared and analyzed the characteristics of changes in their financial conditions for each category assigned, according to a corporate ranking of construction companies. Among the top 50 publicly traded companies of the construction capability index in South Korea, 28 companies were selected and analyzed in two groups: 14 upper and 14 lower companies. The quarterly data collection covered the period between Q1 2004 and Q4 2010. Confirming the a priori assumption, the upper group had better financial stability than the lower group. The financial condition of the lower group was insensitive to economic fluctuations. That is, we confirmed that a smaller company remained in the same aggravated financial condition. While the upper group companies had better financial stabilities than the lower group companies did, they tended to respond very sensitively to economic fluctuations. We verified that the upper group companies were more likely to incur conspicuous aggravation of financial situations under an abrupt economic fluctuation compared to the lower group companies.

Keywords: Financial Condition, Construction Companies, KMV Model, Expected Default Frequencies

INTRODUCTION

According to statistics of The Construction Association of Korea, 522 Korean construction companies underwent bankruptcy in 1998 alone, the year of the IMF financial crisis in Korea. 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).

Korea entered in an economic depression triggered by the subprime mortgage crisis in the US, and the construction industry also went through crises associated with internal and external risk factors, including insolvencies of project financing (PF) due to unsold houses. In particular, the issues in the housing market caused the construction industry serious cash flow problems.

Because the construction industry involves multiple stakeholders, a company's financial problems can cause a series of domino-effect insolvencies of, for example, banking institutions, as well as of the construction company itself. Therefore, an analysis of the management characteristics of a construction company is very important in the rapidly-changing economic environment.

While various business areas, including manufacturing and service, have engaged in studies of management

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conditions, construction companies lack analyses of their financial conditions. In addition, we found that studies about expected defaults of construction companies only included simple analyses, using general financial ratios. As aggravated financial situations of construction companies can heavily affect related stakeholders, they need a thorough evaluation of their financial conditions and business environments.

Therefore, we used the KMV (Kealhofer, McQuown and Vasicek) model, developed on the basis of the Black-Scholes option pricing theory, to calculate expected default frequencies (EDFs) of construction companies. We compared and analyzed the characteristics of changes in the financial conditions of 28 construction companies, selected out of the top 50 domestic companies on the Korean construction capability evaluation of 2011. We classified the 28 companies into two groups: 14 upper and 14 lower companies, according to their ranks on the construction capability evaluation. To measure EDFs from the KMV model, we calculated asset values, asset value volatilities, and default points, followed by the distances to default, and finally the quarterly EDFs for the period spanning from Q1 2004 to Q4 2010. The analysis variables were the total market values, stock volatilities, financial information, and volatilities of the companies, all of which we obtained from TS2000 of Korea listed companies association, and the risk free rates. The risk free rates were the interest rates of a three-year government bond, provided by Statistics Korea. The periods of the variables ranged from Q1 2004 to Q4 2010, and daily stock prices and quarterly financial data were also used.

BACKGROUND

Changes in the financial conditions of Korean construction companies

Not only do changes in the financial conditions of construction companies affect the companies themselves, they also substantially affect construction projects and multiple stakeholders. In particular, the worst economic conditions of domestic construction companies were caused by macroeconomic changes. Tables 1 and 2 show the trends of major construction indices during the IMF and subprime financial crises, indicating the points when insolvencies of construction companies abruptly soared, with the major construction indices increasingly worsening during those financial crises. In particular, during the IMF financial crisis in 1998, bankruptcies of construction companies reached 522 cases, the maximum number in history, due to the ailing construction industry. Despite the smaller number of bankruptcies during the subprime financial crisis, the construction market has still not recovered from the depression. That is, many construction companies have barely avoided bankruptcy, while still suffering from the aftermath of the distressed construction industry.

Moreover, since operational capabilities and business structures differ from company to company, changes in financial conditions are expected to differ. Thus, reviewing trends of the management conditions of construction companies may extract meaningful implications, based on the data from the construction capability evaluation and the results of comparing and analyzing the characteristics of the management conditions. Therefore, we calculated EDFs based on the KMV model and performed comparative analyses of the characteristics of changes in the financial conditions of the two groups of construction companies.

Literature review

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

Kangari (1988) stressed that construction companies should recognize the possibility of business failure and the importance of consistent monitoring of their financial status using financial ratios. Kangari et al. (1992) presented a quantitative model by 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 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 used 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. Using multivariate regression analysis, Lowe and Moroke (2010)

Table 1. Trends in the major construction indices before and after the IMF financial crisis

Index	Unit	Year				
		1996	1997	1998	1999	2000
Project amount	(100 million KRW)	687,490	749,240	470,802	471,677	499,363
Approved sizes of construction	1,000㎡	113,820	113.374	50,965	72,533	81,059
Unsold apartments	Apartment unit	88,867	102,701	70,872	58,550	31,512
Bankruptcies	Number	196	291	522	112	132

Data: Construction Association of Korea

Table 2. Trends in the major construction indices before and after the subprime financial crisis

Index	Unit	Year				
		2006	2007	2008	2009	2010
Project amount	(100 million Won)	1,073,184	1,279,118	1,200,851	1,187,142	1,032,298
Approved sizes of construction	1,000㎡	133,271	150,957	120,658	105,137	125,447
Unsold apartments	Apartment unit	73,772	112,254	165,599	123,297	88,706
Bankruptcies	Number	106	120	130	87	86

Data: Construction Association of Korea

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 demonstrated its effectiveness by comparing their model with existing logistic regression models. Al-Joburi et al. (2012) examined negative cash flow trends, patterns of construction performance, and their impacts on construction company bankruptcy, and found that the amount, duration, and distribution of negative cash flow are critical contributing factors.

However, these previous studies have some weaknesses. First, it is difficult to get timely information because variables for analysis are available only periodically (Hillegeist et al., 2004). Second, the models were constructed by comparing defaulting and non-defaulting firms to determine the variables that discriminate between them (Gharghori et al., 2006). Third, the parameters for analysis 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, both academics and analysts 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 and quantitative information, as well as a corporation's internal and external conditions. An option-based model can be used for predicting bankruptcy in construction companies (Tserng et al., 2011a). Tserng et al. (2011a) estimated the bankruptcy probability of construction companies in the U.S. by using three kinds of option-based credit models, demonstrating that an option-based credit model was a good alternative model for bankruptcy prediction of construction companies.

Because the condition of the construction industry is closely related to macroeconomic fluctuations, it is important to understand the status of insolvency of a given construction company before and after a macroeconomic fluctuation, and to quantify its recovery following a specific economic event. Keeping this point of view in mind, we reviewed the characteristics of the processes by which the selected construction companies went into insolvency, using the KMV model.

KMV model

Merton's corporate bankruptcy prediction model is a structural approach in which the Black-Sholes option pricing model is used to develop a theoretical credit risk measurement model because it treats the likelihood 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 as the underlying asset, and the debt value that has to be repaid by the company as 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 the Black-Sholes and Merton models as option price models, predicts that default or bankruptcy will occur when the corporate asset value drops below the default point (Lee, 2011). However, it is difficult to reflect current information using models that are based on existing financial statements only, because the reporting period for financial information is not continuous. 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 on 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 investigated the precision of the KMV model using empirical analysis. Kurbat et al. (2002) examined the KMV model by level verification and analysis of calibration, and showed that the KMV model was very useful using three years of data from 1,000 U.S. companies. Crosbie et al. (2003) picked financial firms as samples to check the KMV model and verified that this model is an effective method for estimating the default risk. Korablev et al. (2007) regarded the KMV model as a very 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).

An EDF calculated based on the KMV model measures the degree of insolvency of a company, specific to time; therefore, an accumulation of time series for analysis can parameterize the process of insolvency of a company. We defined the degree of insolvency of a construction company as the EDF and used it as an analysis variable.

Summary of analysis sample and variable selection

Selection of analysis sample

The analysis sample consisted of 28 companies, classified into two groups, namely, the upper 14 and the lower 14 construction companies from among the top 50 publicly traded companies on the construction capability evaluation of 2011. The period of the sample data spans from Q1 2004 to Q4 2010. We calculated the quarterly EDFs of the construction companies and performed comparative analyses of the characteristics of changes in the business conditions of the two groups (See table 3).

Selection of analysis sample

To calculate an EDF using the KMV model, analysis variables including an asset value (V_E), asset value volatility (σ_E), financial data, and a risk free rate (r_f) were needed. We obtained the asset value (V_E) and asset value volatility (σ_E) of each construction firm from its daily stock prices and the number of shares from Q1 2004 to Q4 2010. If the yield ratio of stock is based on continuous compounding, volatility is defined as the standard deviation of the yield ratio, shown in Formula (2). According to Formula (1), asset value volatility is the standard deviation of the natural logarithm to the year-end stock price. Further, the financial data include the net worth excluding the short-term and long-term debts of a company. Financial data of a company were the disclosed financial statements of each company from Q1 2004 to Q4 2010. The risk-free rate is the rate that has no risk of default. It is common to use the interest rate of a government bond, which is considered free of default, as the risk-free rate. Thus, we used the interest rate of a three-year government bond from Q1 2004 to Q4 2010.

$$\ln S_t \sim \Phi\left[\ln S_0 + \left(\mu - \frac{\sigma^2}{2}\right)T, \sigma\sqrt{T}\right] \quad (1)$$

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\upsilon_i - \bar{\upsilon})^2}$$

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\upsilon_i^2 - \frac{1}{n(n-1)}\left(\sum_{i=1}^{n}\upsilon_i\right)^2} \quad (2)$$

Table 3. Summary of analysis sample (Unit: Million KRW)

Classification	Rank	Amount of construction capacity	Classification	Rank	Amount of construction capacity
A1	2	10,213,211	B1	26	1,326,308
A2	3	8,518,609	B2	27	1,322,677
A3	5	7,363,220	B3	28	1,283,247
A4	6	6,891,887	B4	29	1,227,064
A5	8	3,928,993	B5	30	1,156,708
A6	10	2,743,798	B6	32	1,059,010
A7	12	2,701,978	B7	35	1,008,607
A8	13	2,253,780	B8	36	1,001,676
A9	14	2,159,525	B9	38	897,062
A10	16	1,928,126	B10	39	872,144
A11	17	1,889,323	B11	41	717,210
A12	18	1,769,364	B12	45	615,236
A13	19	1,767,880	B13	48	597,465
A14	20	1,709,136	B14	50	555,586

those three factors, we obtained an EDF.

$\Phi[a, b]$: Normal distribution with average a and standard deviation b

$\upsilon_i = \ln\left(\frac{S_i}{S_{i-1}}\right)$ for i = 1, 2,....., n

n: stock price number

Empirical analysis

We used the KMV model to calculate an EDF and used it as a proxy variable that indicates insolvency of a construction company. Figure 1 shows the calculation route of an EDF. First, we estimated the asset value and asset value volatility, and then determined a default point (DP). Using Table 4 and Figure 2 show the expected default frequencies of the upper and lower groups of the 28 construction companies from Q1 2004 to Q4 2010. The trend of the EDFs of each company was distinctive: the financial conditions of the construction industries have improved as the housing market started to recover at the beginning of the new millennium. Some companies improved more rapidly than others, with the capacity of each company determining the speed of recovery from insolvency. In addition, the subprime financial crisis of 2008 accelerated aggravation of the construction market, worsening the financial conditions of construction companies overall. Again, the degree of worsening differed from company to company.

Estimation of asset value and asset value volatility	(1) $V_E = V_A N(d_1) - V_D e^{-r_f T} N(d_2)$ (2) $d_1 = \frac{\ln(V_A/X) + (r_f + \sigma_A^2/2)T}{\sigma_A\sqrt{T}}$ (3) $d_2 = d_1 - \sigma_A\sqrt{T}$ (4) $\sigma_E = \frac{V_A}{V_E} N(d_1) \cdot \sigma_A$ V_E : Stock value of company V_A : Asset value of company V_D : Total book value of debt r_f : Risk free rate σ_A : Volatility of asset value T : Maturity date of debt N( ) : Cumulative distribution function of normal distribution σ_E : Volatility of stock value
Determination of a default point (DP)	(5) Default Point = STD + 0.5 × LTD Default Point : Default point STD : Short term debt LTD : Long term debt
Determination of a distance to default (DD)	(6) $DD = \frac{\ln(V_A/DP) + (\mu - \sigma_A^2/2)T}{\sigma_A\sqrt{T}}$ V_A : Asset value of company DP : Default point μ : Growth rate of return on asset σ_A : Volatility of asset value T : Maturity date of debt
Calculation of an expected default frequency (EDF)	(7) $EDF = Cum(-DD) = N(-d_2)$

Figure 1. Calculation route of an EDF

Table 4. Average EDFs of construction companies per time point and group

Year/Quarter	EDF	
	Upper group	Lower group
2004/01	0.7981	0.9102
2004/02	0.8168	0.9201
2004/03	0.7688	0.9081
2004/04	0.7221	0.8731
2005/01	0.7279	0.8651
2005/02	0.7006	0.8356
2005/03	0.6419	0.7931
2005/04	0.5612	0.7687
2006/01	0.6004	0.7917
2006/02	0.6462	0.8096
2006/03	0.6027	0.7929
2006/04	0.5431	0.7709
2007/01	0.5524	0.7890
2007/02	0.4256	0.6859

Table 4 cont.

2007/03	0.3916	0.6910
2007/04	0.4476	0.7400
2008/01	0.5605	0.8004
2008/02	0.6347	0.7869
2008/03	0.7319	0.8863
2008/04	0.8187	0.9125
2009/01	0.8441	0.9274
2009/02	0.8193	0.9126
2009/03	0.7989	0.9091
2009/04	0.7625	0.8996
2010/01	0.7686	0.8990
2010/02	0.8030	0.9066
2010/03	0.7654	0.8885
2010/04	0.7343	0.8752

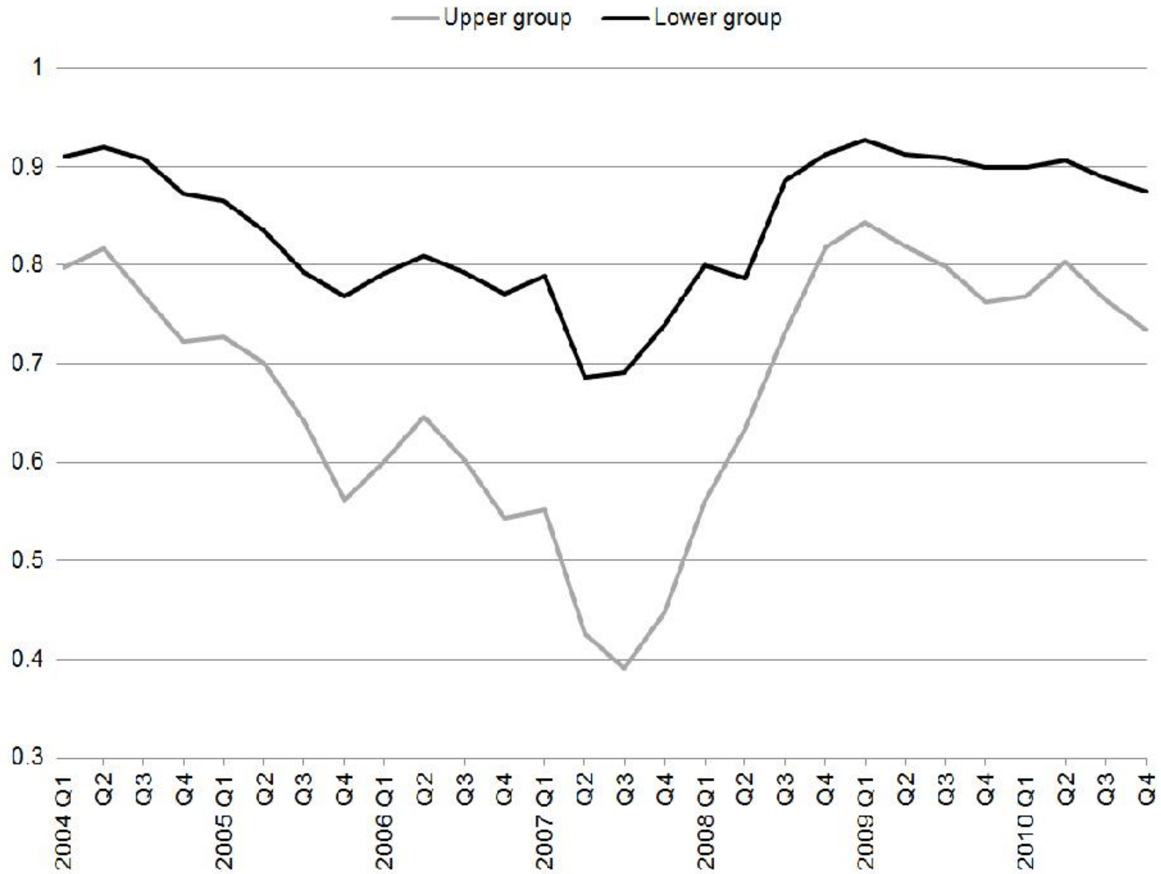

Figure 2. Average EDFs of construction companies per time point and group

The fact that the full sample was classified into two groups of 14 upper and 14 lower companies, and that the EDFs were averaged per scale and time point, enabled comparative analyses of the characteristics of time- and scale-dependent trends. As demonstrated by the analysis, the upper group showed lower EDFs than the lower group, which demonstrates that the former has a stronger financial stability than the latter. However, since 2008 (the year of the subprime crisis), the EDFs of larger companies indicated higher sensitivity to overall economic fluctuations than smaller companies, suggesting that a large company could experience its financial status deterioration more intensely under an abrupt economic fluctuation.

Conclusion

Because the budget of a construction project is enormous, it is generally funded from external sources with the involvement of multiple stakeholders. Moreover, in the Korean financing structure, the construction company commonly guarantees loan payments so that deterioration of the management condition of the construction company substantially affects external stakeholders as well as the company itself. This result stresses the importance of quantifying the change to the financial condition of a construction company. In addition, the characteristics of changes vary depending on the scale of a construction company, such that comparative analyses of the characteristics may extract meaningful implications.

In summary, using the concept of the Merton model based on the option pricing theory of Black-Scholes and the KMV model that was developed based on the concept, we calculated expected default frequencies (EDFs) of construction companies during a specific period and verified the changes in financial conditions depending on the scale of the construction companies. Our sample consisted of 14 upper and 14 lower companies, which were selected from the top 50 publicly traded companies as listed on the construction capability evaluation of 2011. We selected analysis variables to calculate an EDF and obtained the data for each variable from the TS2000 of the Korea Listed Companies association and the corresponding data of Statistics Korea. We then used the data to estimate asset values, asset value volatilities, and default points (DPs), all of which were used to calculate distances to default (DDs), and then finally EDFs. The periods of the data ranged from Q1 2001 to Q4 2010.

The upper group had better financial stability than the lower group, as expected a priori. The financial condition of the lower group was highly insensitive to economic fluctuations. That is, we confirmed that smaller companies keep operating in a weakened financial environment. While the upper group companies had better financial stabilities than the lower group companies, they were very sensitive to economic fluctuations. In the upper group companies, an abrupt economic fluctuation causing rapidly worsening financial situations were intensely felt. Because the structure of the Korean construction industry gives priorities to large companies, small- and medium-sized companies are expected to have difficulties recovering through their usual business activities; they need to improve their financial structures by securing a specialized technology. Additionally, the high sensitivity of large companies to economic fluctuations arises from unbalanced business portfolios trending toward overconcentration. We suggest a diversified portfolio, enabling stable profits resisting fluctuations of the construction market.

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