Yu-Ling Lin & Ta-Cheng Chang

Modeling Corporate Credit Risk with Multiple Debt Issues

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Introduction

In the last several decades, there has been a tremendous wave of interest in the construction of credit risk models to estimate the default probability of borrowers. Following in the footsteps of Altman (1968), who adopted multiple discriminant analysis, Ohlso (1980) conducted a logistic regression analysis of bankruptcy prediction and Zmijewski (1984) implemented probit regression analysis of financial distress prediction. The main theme of these studies is to utilize corporate historic financial variables as explanatory variables and use corporate defaults in the next one or more years as explained variables to establish the discriminant function of default prediction or predict corporate default through Logit and Probit regression models. This analytical framework is called the accounting-based credit risk model in the literature.2

A potential drawback of these accounting-based models is the use of backward-looking accounting information. Hillegeist et al. (2004) argued that the accounting-based models do not take into account the volatility of corporate assets. As a result, these models estimate that firms with similar financial ratios have similar default possibility will have similar default risks. On the other hand, the market-based structural models use the standard European call options of the option-pricing models and follow the Black-Scholes-Merton (Black and Scholes 1973; Merton 1974; hereinafter BSM) model, which assumes that a firm issues a single zero-coupon bond. The BSM structural model views the equity value of a firm as a European call option on the corporate asset value, and uses the market value of corporate equity to estimate the corporate default risk.3 Since the market price reflects an investor's expectation of future corporate performance, this model uses instant forward-looking information to predict corporate defaults. Moreover, firms may have similar equity and debt levels in BSM structural models, but if their asset volatilities are different, their default possibilities will be different as well. Therefore, most studies in the literature suggest that the BSM model, which has decent prediction and discriminant capabilities in corporate default risks, is a better tool for assessing corporate default risks (Shumway 2001; Lin 2002; Hillegeist et al. 2004; Farmen, Westhaard and Wijst 2004; Lin 2005; Benos and Papanastasopoulos 2007).

In the past, some theoretical studies extend the framework of the BSM model. For example, Geske (1977) pointed out that the BSM standard call option model does not consider the condition of a coupon payment before the date of maturity and viewed the corporate debt structure is a coupon bond form and every coupon payment can be regarded as a compound call option form. Black and Cox (1976) considered characteristics such as safety covenants and debt subordination in their bond assessment process. Longstaff and Schwartz (1995) developed an assessment method for corporate bonds that simultaneously considers default risks and interest rate risks. Leland and Toft (1996) examined at the decision of endogenous bankruptcy in light of tax and bankruptcy costs. Collin-Dufresne and Goldstein (2001) proposed a default model considering the leverage ratio. Subsequent empirical studies applied these extensions to evaluate financial instruments instead of predicting default risks. For example, Eom, Helwege and Huang (2004) used the bond data from the Fixed Income Database between 1986 and 1997 to determine the effects of five structural models on corporate bond pricing. These five models include the BSM, Geske (1977), Longstaff and Schwartz (1995), Leland and Toft (1996), and Collin-Dufresne and Goldstein (2001).

Yu-Ling Lin is Assistant Professor of Department of Banking and Finance, Takming University of Science and Technology. Ta-Cheng Chang is Professor of Department of International Business, Soochow University.

2 The literature related to ‘utilizing accounting-based credit modeling for default risk measurement’ in Taiwan includes: Lin (2002), Chen, Wang and Hsu (2004), Shen and Lin (2005), Lin (2005), Su and Lin (2006), and Huang et al. (2008).

3 Compared to using corporate capital structure to establish the structural model for predicting the default rate, another market-based reduced form model that is independent of the corporate balance sheet uses bond market data to evaluate credit risk. Since this model is based on a theoretical assumption that lacks economic implications, and the bond market in Taiwan is relatively less mature than the stock market, the application of this method on the evaluation of corporate default risks may face some restrictions (Lin and Lin 2004; Su and Lin 2006).
Results indicate that all these models have significant errors in corporate bond pricing: Longstaff and Schwartz (1995), Leland and Toft (1996) and Collin-Dufresne and Goldstein (2001) overpredicted the spread in corporate bonds, while BSM and Geske (1977) underpredicted it. Errors were not so serious in the Geske (1977) model. This implies that the endogenous default boundary of the Geske (1977) model may be able to improve the pricing capability of the BSM model to corporate bonds.

The prediction of corporate defaults is an important topic in current academic and practical research. Most previous studies in the literature confirm the good default prediction ability of the BSM model (Lin 2002; Hillegeist et al. 2004; Lin 2005; Benos and Papanastasopoulos 2007). However, most of these studies compare the prediction ability of accounting-based and BSM credit risk models or focus on the theoretical improvement of the BSM model (Black and Cox 1976; Geske 1977; Longstaff and Schwartz 1995; Leland and Toft 1996; Collin-Dufresne and Goldstein 2001; Chen, Wang and Hsu 2004; Lin 2005; Su and Lin 2006). Furthermore, previous studies lack a theoretical discussion about the establishment and improvement of default prediction models and an empirical verification and exploration of the BSM model. Therefore, the simplifying assumption of the BSM model has been relaxed in the establishment and practical exploration of default risk models. Research studies on this topic are few, and thus it is the main purpose of this study. The assumption of the BSM quantitative credit risk model that a firm only issues a single bond does not fit well with the usual corporate debt structure. Therefore, this study utilizes the compound option (hereinafter CO) model in exotic option theory to relax the over-simplified assumptions of the BSM model. This step improves the over-simplified debt structure form of the BSM model and allows relevant analysis.

This study assumes that a firm has two debt structures. This assumption improves the deficiency of the single debt structure in the BSM model and helps establish a structural credit risk measurement model that agrees better with more realistic debt structures. This study also reveals the causes of the difference in the prediction performance of the BSM and CO models. To the best of our knowledge, this study may be the first in Taiwan that utilizes two different debt structures and the compound option theory to extend the BSM model in the establishment of a quantitative credit risk model and explains the reasons for the differences in the predictive ability of these two structural models through Tobit regression. Results indicate that the prediction abilities of the BSM and CO models increase as the prediction time approaches the occurrence of default. Establishing a default warning model that agrees with the more realistic economical and social debt structure should improve the default prediction ability of the BSM model.

Research Method

This study adopts a two-stage approach using the structural models and a Tobit regression. First, we use the BSM and CO structural models to estimate the default probability of the firms, observing the default prediction performance for each model. Second, we employ the Tobit regression model to reveal causes of the differences in the default prediction performance of these two structural models.

The structural models and the measurement of predictive ability

1. The BSM model

Merton (1974) used the Black and Scholes (1973) option-pricing model to value corporate liabilities on the basis of such liabilities being contingent claims on firm assets. The capital structure of a firm in the BSM model comprises equity and a zero-coupon bond with maturity $T$ and face value $F$. The asset value of the firm is simply the sum of the value of its equity and bonds. Under these assumptions, the equity of a firm can viewed as a European call option on the firm’s value of assets, with a strike price equal to the book value of the firm’s debt $F$ and a debt maturity $T$.

2. The CO model

This model assumes that the corporate debt structure contains two debts with different maturity dates: one is with shorter and the other is longer. When the corporate short-term debt or long-term debt is due, there is a probability of default. If a firm has enough capacity to repay the expected debts when short-term debts become due, but cannot repay when long-term debts are due, then a default will also occur. In other words, CO models should consider both of these default risks simultaneously when estimating the overall default risk. If the firm issues short-term and long-term pure discount bonds, then the short-term debt $F_1$ becomes due at time point $T_1$, long-term debt $F_2$ at $T_2$, where $T_2 \geq T_1$. The CO model in this study is a two-period model with two maturity date structure debts, which can be indicated through the Geske (1977, 1979) compound call option theory.

3. Analysis of the predictive ability of the models

This study computes the three absolute values of area under the curve (AUC), accuracy ratio (AR), and Kolmogorov-Smirnov statistics (KS) using the ‘receiver operating characteristics’ (ROC) curve, the ‘cumulative accuracy profiles’ (CAP) curve, and the ‘Kolmogorov-Smirnov’ (KS) test, respectively. These three values make it possible to further investigate the default prediction performance of the two structural models. Larger values of AUC, AR, and KS indicate better prediction ability of the structural models.
Tobit regression analysis

To determine the factors influencing the prediction ability of the structural models, this study also conducts a regression analysis on market and financial variables for the default probability estimation of the structural models. Since the default probability is the dependent variable, the regression model in this study is a censored sample model, where independent variables correspond to any observation values, but dependent variables correspond only to certain observation values. The estimated parameters generated by the ordinary least square (OLS) approach can be biased and inconsistent. Therefore, this study uses the Tobit regression model to examine the influence of relevant default variables on default probability.

Research Data

The sample in this study comprises all listed companies in Taiwan, along with variable data taken from the Taiwan Economic Journal (TEJ) database. A series of cases of financial distress have occurred in Taiwan since 1998, including dishonored checks, misappropriation of assets, and defaults in the delivery of securities. We selected 118 listed companies in Taiwan which defaulted between 1998 and June 2006.4 ‘Normal’ companies are other listed companies with no reported defaults and with continuing normal operations as of June 2006. These companies each had positive net values during the prediction periods. This study considers a total of 690 listed companies.

Results

Comparison of the predictive ability of the models

An application of the BSM and CO structural models, which both contain market stock price information for predicting corporate defaults, shows that the closer the prediction time is to the default time, the better the default prediction ability. This is because the stock price will more accurately reflect better market information closer to default. The occurrence of defaults has serious impacts on society. Since the BSM model can predict short-term corporate defaults, it may help decrease the loss caused by defaults. However, the CO model proposed in this study, which is established on the compound option theory, is better able to predict corporate default than the BSM model for both short-term or long-term periods. Therefore, applying the CO model to measuring corporate default risks can not only portray a corporate debt structure that agrees with realistic conditions, but can also be the basis for implementing precautionary measures. This is favorable to financial institutions because they have enough time to take on recoverable debt before corporate default, thus greatly decreasing the probability of default which naturally causes an enormous social impact. Therefore, the CO model can be used as another optional tool for default estimation.

Differences in the prediction ability of the models

The empirical results of the default risks evaluated by the BSM and CO structural models have significant statistical differences. Further analysis through the Tobit regression model shows that the CO model presents a more comprehensive and complete picture. This is because the indicator for default risks in the CO model considers corporate solvency, profitability, and market information factors, while that of the BSM model only considers solvency and market information factors in the establishing process. Therefore, as predicted in this study, the CO model can detect the default conditions of corporate profitability problems more effectively than the BSM model, and the CO model has a better default prediction ability than the BSM model.

Conclusion

Most previous studies on quantitative credit risk models recognize the BSM model as a good tool for evaluating corporate default risks. However, the BSM model assumes that a firm only issues single zero-coupon bond, which does not in fact agree with realistic corporate debt structures. Therefore, this study attempts to improve these measures by considering a corporate debt structure that agrees well with the realistic conditions of an economy under the establishment of a general CO credit risk quantification model.

Unlike the BSM single debt structure, the CO model assumes that the corporate debt structure has two different dates of maturity. Therefore, this study introduces a compound option theory to establish the two-period credit risk model. By detecting AUC, AR, KS, and evaluating the default prediction ability of models, this study concludes that these two structural models are both appropriate for the measurement of short-term default prediction. The default prediction ability of the proposed CO model is better than that of the BSM model, which traditionally utilizes market information for estimation. This indicates that an over-simplified assumption does have an impact on the model's prediction ability.

4 This study adopts the TEJ definition of financial distress, where default is defined as the occurrence of any of the following events: bankruptcies and closures, restructuring, dishonored checks, bailouts, takeovers, accountant’s questions on the company’s prospects as a going concern, negative net value, delisting, or suspension of operations due to tight financial situations. Although the finance and insurance industry has a significant influence on the country’s finance system, their accounting systems differ from those of other industries due to the uniqueness of their business. Since such accounting differences may lead to problems in data matching, the sample does not include any of the firms in this industry.
Utilizing the proposed CO model to detect default companies can help improve the default predictions of the BSM model, which only considers single zero-coupon debts defaulting at maturity and those having lower default discriminatory power caused by a conservative evaluation of corporate default risks. As a result, this study believes that the CO model can be used to establish quantification indicators and evaluate credit risk quantification of financial institutions in Taiwan under the New Basel Capital Accord.

REFERENCES


Credit risk modeling is a great tool to understand the credit risk of a borrower. Read more to know what credit risk modelling is all about. For individuals, this score is based on their debt-income ratio and existing credit score. For institutions that issue bonds, this probability is determined by rating agencies like Moody's and Standard & Poor's. The PD generally determines the interest rate and amount of down payment needed. Register For a Free Webinar.

Credit Risk Modelling Challenges (vs Market Risk)
- The lack of a liquid market. Makes it difficult to price products
- Time horizon tends to be longer than for market risk
- Requirement for more refined simulation techniques (evolution of exposures)
- Capital Adequacy calculations. Tails of asymmetric fat-tailed distributions.

Reinsurance Credit Risk Modelling
- The Loss Process
- Diversification and Correlation
- Rating Agency Studies
- Modelling Issues
- Numerical Examples

Asset Return vs Default Correlation.