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On long-term credit risk assessment and rating: Towards a new set of models

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On long-term credit risk assessment and rating: Towards a new set of models

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Institutional investors are supposed to assess credit risk by using a combination of quantitative information such as option models and qualitative assessments. Although option models can be easily constructed, they are not so suitable for the assessment of long-term credit risk that is required by institutional investors. This is mainly because the probability of bankruptcy varies so widely depending on the timing of assessment. We propose a new set of assessment models for long-term credit risk which does not necessarily use stock prices and may incorporate business cycles. The new grand model consists of the two pillars: a long-term cash flow prediction model and a credit risk spread assessment model. The calculated values derived from these models are effectively usable for reasonable calculation of risk spreads. It is quite interesting to see that our investigation indicates that rating bias may exist in the credit risk assessment of the market.

Key words: risk assessment, rating, bankruptcy, cash flow prediction, credit risk spread

I. Introduction

In the business world today, both investment and information are so important that they constitute complementary factors. Investment without information would lead businessmen nowhere, whereas information without investment would be like an empty box.

By making use of a variety of information, institutional investors are supposed to make two critical decisions: investment/finance and credit risk spread decisions. The credit risk spread is meant by the difference in interest between a government bond and a corporate bond in the relevant period. Concerning business information, “quantitative information” obtained from option and other models must be dealt with distinctively from “qualitative information,” namely information other than financial statements plus ratings by credit-rating agencies.

In our opinion, option models can be roughly classified into “structural models” and “induction models.” Structural models are used in determining the probability that the market asset value of a given corporation falls short of its amount of debt, thus indicating the probability of bankruptcy. The distribution of the market asset value is calculated using the asset value and its volatility. The induction model, however, does not consider the mechanism per se determining the probability of bankruptcy, but rather assumes that the mechanism is exogenously given by the Poisson process or the like.

In his nice paper, Takao Kobayashi (2003) discussed the two option models aforementioned with limited success. First, his argument is based on the assumption that the probability process depends on a geometric Brownian motion, so that the process is presumed to continuously vary over time without any jump. As a result, the Kobayashi model is not so suitable for the analysis of a more realistic situation of sudden bankruptcy. Second, since in his model disclosed balance sheets are automatically accepted as such, substantial noise remains to be present in the final outcome even if any window dressed financial statements are included.

In order to deal with those difficulties, Zhou (2001) has proposed a model incorporating a potential jump into the probability process. Duffie and Lando (2001) has suggested an interesting technique for embedding potential incompleteness of accounting information into a model, thus making continuous improvements of the model possible.

With these previous contributions as its background, the Bank of Japan has adopted its Examination Policy for Fiscal 2006 and requested all associated financial institutions to verify the accuracy of credit risk assessment using quantitative models. It also asked them to establish long-term credit risk assessment methods reflecting business cycle in the real economy.

The purpose of this paper is twofold. First, we attempt to mend possible weaknesses of the option models by reviewing their questionable features on the basis of the Japanese economic data. Second, we propose a new model for long-term credit risk assessments in response to the urgent needs of institutional investors today.

2. Verification of option models using data on Japanese industries

The question of interest is what kind of tasks institutional investors should do to ensure appropriate management of their investment/financing portfolios. They do not only credit risk assessments made at the time of investment and/or financing but also continuous monitoring of credit risk throughout the period of the investment/financing.

In order to verify the serviceability of option models, changes in probability of bankruptcy calculated by option models are to be observed at continually changing measurement points. For this purpose, the Black-Scholes-Merton model (hereinafter referred to as the "BSM model") and the First Passage model (hereinafter the "FP model") are employed since they are representative of structural models. The difference between the two models is that the BSM model calculates the probability of bankruptcy at a single time point after five years have elapsed, whereas the FP model provides the probability of bankruptcy taking place during the whole financing period of five years. Interestingly enough, the former and the latter respectively correspond to the American and the European option.

With the first BSM model, a company is defined as being in default or bankruptcy if its corporate value shown by aggregate market value falls short of its amount of debt, or namely aggregate market value minus equity capital. As a simplified example of this, let us assume that a company has issued only one discount bond with a par value of D and redemption date T. Then it is deemed as having defaulted if its corporate value, At, is below the par value D of the corporate bond at redemption date T. More specifically, Once a probability model of corporate value, At, over a course of time is determined, the probability that this corporate value will fall short of D at future time point T can be calculated.

In what follows, let μ represent the projected growth rate of corporate assets or the average growth rate of aggregated market value every month over the past three years, and let σ denote the volatility of At. Besides, let $p(t,T)$ stand for the survival probability of a company over the period of current time point t through to future time point of T. Then $p(t、T)$ may be expressed using the following formula:

$$p(t,T) = \Phi\left[\frac{X_t + m(T-t)}{\sqrt{T-t}}\right]$$

On the other hand, with the second FP model, we can express $p(t,T)$ in a more complicated formula. It is noted that this second formula includes a second extra term in addition to the first formula used for the BSM model.

$$p(t,T) = \Phi\left[\frac{X_t + m(T-t)}{\sqrt{T-t}}\right] - e^{-2mX_t}\Phi\left[\frac{-X_t + m(T-t)}{\sqrt{T-t}}\right]$$

where $X_t = \frac{\log(A_t/D)}{\sigma}$ and $m = \frac{\left(\eta - \frac{\sigma^2}{2}\right)}{\sigma}$. Note that η represents the projected growth rate or the annual rate of change in market asset value, σ its volatility or standard deviation, and Φ a cumulative distribution function of the standard normal distribution. Besides, X_t is obtained by dividing the rate of market asset value to debts by risk or standard deviation, thus representing the so-called “distance to default."

For the purpose of our research , the probability of bankruptcy within five years, 1-p (t ,T) is calculated for companies listed in the first section of the Tokyo Stock Exchange, which includes the probability of bankruptcy of twenty industries in each of the months from September 2005 to July 2007.

Figure 1 gives the changes in probability of bankruptcy of all industries (for both BSM and FP models), the electric appliance industry (for BSM model), financial industry (for BSM model) and Sharp as a firm belonging to the electric appliance industry (for BSM model). The twenty industries used in the calculations include the following: (1)fishing, agriculture and forestry, (2) mining, (3) food, (4) textile, (5) paper and pulp, (6) chemical, (7) pharmaceutical, (8) oil and coal, (9) rubber, (10) glass and quarrying, (11) steel, (12) non-ferrous metal, (13) metal products, (14) general machinery, (15)electric appliance, (16) transportation machinery, (17)precision machinery, (18) miscellaneous products, (19) financing, and (20) construction industries.

The probability of bankruptcy indicated by the bar graph in Figure 1 is seen to widely vary over each of the months. After regaining stability in 2006, it again rose rapidly from 2007 when the subprime loan problem in the United States started attracting attention in financial markets. While the probability of bankruptcy of all industries with the BSM model was stable at around the 5% level, the probability with the FP model was often beyond 30% in and after 2007, thus indicating that the probability of bankruptcy occurrence within five years is rapidly increasing.

As is seen in Figure 1, all industries tend to show cyclic changes, while the probability in the electric appliances industry varies so widely. The financial industry, on the other hand, has had rapidly increasing probability of bankruptcy since fiscal 2007. The probability of bankruptcy with Sharp, which is represented by the broken line, was very high in fiscal 2005 due to intense competition throughout the industry, but steadily has moved to a lower level from fiscal 2006, thus reflecting the rise in the global stock market. The movement with Sharp was rather stable in comparison with the probability of bankruptcy of all industries.

While the FP model has a variety of merits, there exists a main disadvantage with it: The probability of bankruptcy revealed by it can substantially vary with different measuring time points. This requires us to make a set of extra assumptions such as the assumption "the company will maintain their debt ratio at around a certain target value" when we apply it to long-term credit risk assessments.

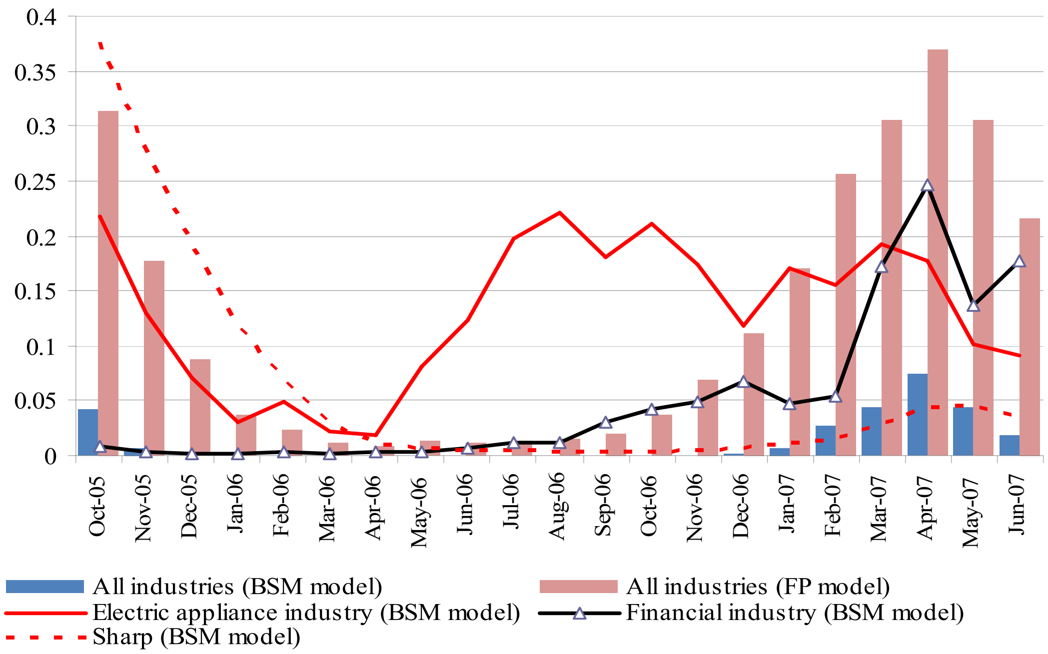

Figure 1. Changes in probability of bankruptcy by option model

3. Incorporation of business cycles

There is a wide variation in the probability of bankruptcy of the option model, depending on the measurement of time point. This indicates the need for a mechanism reflecting changes in the macroeconomic environment such as business cycles, which will enable us to apply the model to long-term credit risk assessments.

Generally speaking, people intuitively understand that economic recovery leads to temporary improvements in financial statements and reduction of credit risk for companies. It can easily be seen that in the expansion phase upgraded companies will increase in number, whereas in the contraction phase the number of downgraded companies will go up.

Figure 2 tells us the periodical occurrence of business cycles in Japan as well as changes in credit risk over the past thirty-eight years. The shaded areas indicate the duration of economic recessions, based on reference date on the business cycle announced by the Cabinet Office, while the solid line stands for the year-on-year changes of bankruptcy rate for the current and previous years, thus representing the degree of credit risk. It is noted that the bankruptcy rate is obtained by means of dividing the number of bankruptcies (reported by the Tokyo Shoko Research) by the number of ordinary corporations (reported by the National Tax Agency). The rate of change in the bankruptcy rate shown by the solid line rises sharply in the phases of economic recessions from the peaks to bottoms, which certainly reveals a close affinity with business cycles.

In order to estimate the rate of change in the bankruptcy rate, we selected many necessary variables from the diffusion index (leading index) announced by the Cabinet

Office and the Nikkei Stock Average change rate of the previous year. The estimated period was from fiscal 1971 to 2008 (from April to December for fiscal 2008 only). We want to avoid any serial correlation, so the model used here was multiple regression analysis together with auto regression analysis for the residual. The explanatory variables were selected using Akaike Information Criterion and the value of t. The fact that the rate of bankruptcy is influenced by the Nikkei Stock Average change rate of the previous year may indicate a certain level of reasonability of the option model that estimates the probability of bankruptcy using stock prices. But it also suggests that the model is not so suitable for long-term credit risk assessments for more than two years.

The broken line on the graph gives the estimated rates of bankruptcy. Although the estimated rates of bankruptcy do not fully stay in line with the changes that occurred in development and settlement periods of the bubble economy of 1987 to 1993, they do so adequately with changes in other phases. The highest increase in the estimated value can be observed in the latest period due to the influence of global financial instability and the world-wide economic depression, thus indicating that the bankruptcy rate will rise even further in Japan.

The upper figures in the graph show the cumulative rate in change of the bankruptcy rates over five years from economic peaks. Averaging the bankruptcy rate of the eight business cycles during the past thirty-eight years reveals that it increases by 13.7% for the five years after economic peaks, whereas it also goes up in six phases during the eight business cycles. In economic peak phases, in which usually larger funds are needed, long-term loans are highly likely to have their credit risk increased in comparison with what they were at the beginning.

To sum up, the above arguments show that when we build a model for assessing long-term credit risk, the model need to incorporate many business cycles between peaks and bottoms.

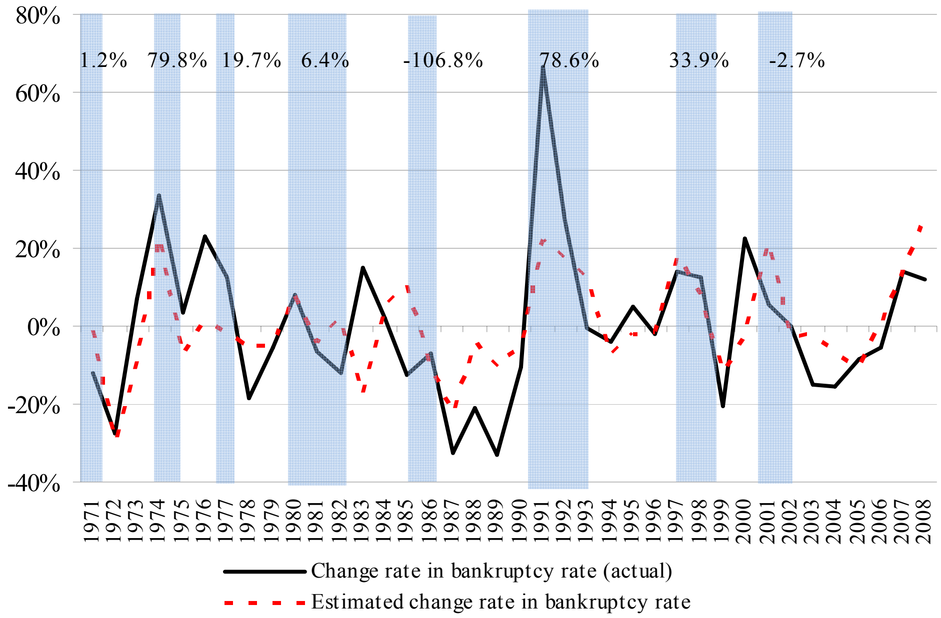

Figure 2. Estimation of bankruptcy rate in Japan

Note:

1. The shadow areas indicate the contraction phases based on the reference dates of business cycles. The upper figures in the graph are changes in bankruptcy rates for the 5 years after economic peaks (- represents improvement).
2. Change rate in bankruptcy rate (t) = 0.35437- 0.00650 * (leading diffusion index)

   < -3.987 >

   - 0.0232 * (change rate of stock price in previous term)

   < -2.361 >

   + 0.18823 * (change rate in bankruptcy rate)

   < 1.070 >

   + 0.00650 * (leading index of business conditions (t-1))

   + 0.0232 * (change rage of stock price in previous term (t-1)) – 035437)

   The estimation period is from fiscal 1972 to 2008 (April through to December for fiscal 2008 only). The figure in < > represents value of t. The Akaike Information Criterion is -30.879, and the log likelihood is 19.440. The auto-correlation coefficient is within the confidence limit up to the lag 16th term and the residual is noise.

4. Method of Analysis

4.1 A Long-term cash flow prediction model

As may be clear from the above discussions, there are four disadvantages of the structural model. First, the model tends to fail to reflect the situation in which a company suddenly goes bankrupt. Second, window-dressed financial data etc. can result in excessive noise in the distance to default. Third, it is subject to the influence of stock prices, thus resulting in wide variations in the estimated bankruptcy rates. Four, it does not allow the business cycles which are necessary in determining long-term credit risk to be incorporated.

To deal with these four disadvantages, we want to propose a new kind of grand model. First, the downtrend risk of a company will be identified in advance through stress testing to be discussed below. Second, the influence of window-dressed data will be suppressed so that the model is based on a company's profit structure rather than the interaction between highly volatile corporate value and debts. Third, the model structure will be designed so as not to use highly volatile stock prices. And last, the model will be developed so as to reflect business cycles in predictive values.

More specifically, a company's cash flow structure is modelled and a probability distribution using the Monte Carlo simulation is used in the prediction in order to calculate the probability of current account deficits and the credit risk spread. The new grand model is made up of the following two models. They are: a "long-term cash flow prediction model on industries and corporations" that may predict a company's long-term cash flow: and a "credit risk spread assessment model" that uses a Monte Carlo simulation to calculate the credit risk spread.

The long-term cash flow prediction model on industries is structured as follows:

$$R_t = \alpha_1 + \alpha_2 GDP_t + \alpha_3 PP_t + r_t \qquad r_t = \alpha_4 r_{t-1} + u_t$$
$$E_t = \beta_1 + \beta_2 GDP_t + \beta_3 PP_t + r_t \qquad r_t = \beta_4 r_{t-1} + u_t$$
$$C_t = \gamma_1 + \gamma_2 GDP_t + \gamma_3 PP_t + r_t \qquad r_t = \gamma_4 r_{t-1} + u_t$$
$$P_t = R_t - E_t - C_t$$
$$PK_t = \theta_1 + \theta_2 (R_t \times R1_t) + r_t \qquad r_t = \theta_3 r_{t-1} + u_t$$
$$R1_t = \rho_1 + \rho_2 (P_t \div R_t) + \rho_3 I_t + r_t \qquad r_t = \rho_4 r_{t-1} + u_t$$
$$PT_t = \omega_1 + \omega_2 (R_t \times R2_t) + r_t \qquad r_t = \omega_3 r_{t-1} + u_t$$
$$R2_t = \chi_1 + \chi_2 (PK_t \div R_t) + r_t \qquad r_t = \chi_3 r_{t-1} + u_t$$
$$DEP_t = o_1 + o_2 FIX_t + o_3 FA_t + r_t \qquad r_t = o_4 r_{t-1} + u_t$$
$$CF_t = PT_t + DEP_t$$

Note that R, E, C, GDP and PP represent the amount of sales, the one of costs, sales administration expenses, real gross domestic product and corporate goods prices, respectively. In other words, the sales, costs and sales administration expenses of each industry are elucidated using macroeconomic quantity variables and price variables.

Besides, P is defined as P = R－E－C, where P, PK and PT respectively represent the amount of operating profit, the one of ordinary profit to be calculated from R and ordinary profit rate R1, and the one of current profit to be calculated from R and current profit rate R2. Also note that I, DEF, FIX, FA and CF respectively stand for the national bond subscriber's yield that influences a company's payments for interest, depreciation, capital investment, outstanding tangible fixed assets and cash flow. Finally, r, u and subscript t respectively denote residual error, noise and fiscal year. For the purpose of enhancing the accuracy of the predictions, the growth rates from previous year (two-year moving average) are used in R, E, C, DEF, FIX, FA, GDP and PP rather than the actual amounts.

And then, R, E and T of each company belonging to each industry are calculated using the R, E and T of each industry as explanatory variables, whence the P of each company may be specified. Depending on the industry, the P of the company is directly used as the explained variable, with the P of the industry being employed as the explanatory variable in the estimation.

The statistical data used is the Financial Statements Statistics of Corporations by Industry issued by the Ministry of Finance (totally 25,000 companies excluding finance and insurance companies, revised in September 2006) and Middle-term Economic forecasts issued by the NLI Research Institute (issued in October 2006). There are 20 industries used in the estimations over the 35 year period of fiscal 1970 to 2005.

4.2 A Credit risk spread assessment model

We turn to another pillar of our new grand model for long-term credit risk assessment : a credit risk spread assessment model.

We may estimate a credit risk spread by using the operating profit/cash flow calculated from a long-term cash flow prediction model. Although the existing structural model discusses bankruptcy by means of the balance between stock value and debt, our new model defines it in terms of the difference between ordinary losses and shareholder equity. More specifically, as can be seen in Figure 3, there are two approaches conceivable to estimate the credit risk spread.

Let us start with a discussion of the first approach. The case where a cumulative current account deficit exceeds the shareholder equity is deemed a bankruptcy. The probability of bankruptcy is obtained when the number of bankruptcies obtained through a Monte Carlo simulation is divided by the number of scenarios. The credit risk spread may be calculated by means of the probability of bankruptcy. In the Monte

Carlo simulation, 100 different random numbers for each company (totally, 100 different random numbers x 10 years = 1000 random numbers for the whole period) are obtained from past average profit rates and standard deviations. These numbers are to be assigned to each year's operating profit/loss that are calculated using the cash flow prediction model; and the probability of the occurrence of a current account deficit is thus obtained.

Now, let us turn to the second approach. Since we presume that either a higher Probability of an ordinary loss or a smaller shareholder equity ratio results in a higher probability of bankruptcy, we may estimate risk spread by making use of the ordinary loss occurrence probability and the shareholder equity ratio. Note that the latter ratio may serve well as a buffer for deficits.

While our credit risk spread assessment model developed above is compatible with the two approaches, we would like to adopt the second one in this paper, putting aside the first. We may regard this model as a sort of an induction model since we effectively employ the external probability of bankruptcy rather than the internal one.

In the following, four industries are to be analyzed: (1) the steel industry with its high standard deviation of operating profit change rate (more exactly, 1.47 % as twenty-five year average, 89.0 as standard deviation); (2) private railroad industry with its low deviation (3.46%, 7.02); (3) electric appliance industry with its medium deviation (1.03%, 44.5); and (4) the gas industry as an industry of high public interest (1.20%, 25.2).

In terms of individual companies, there are totally the following seventeen companies from five industries, which are intentionally chosen for our investigation.

(1) Four companies from the steel industry: Nippon Steel (with grade AA according to R& I rating, hereafter the same), Sumitomo Metal (BBB), Kobe Steel (BBB) and Nisshin Steel (A-).

(2) Three companies from the private railway industry: Keio Corporation (A+), Odakyu Electric Railway (A-) and Keisei Electric Railway (BBB+).

(3) Six companies from the electric appliance industry: Hitachi (AA+), Toshiba (A+), Panasonic (AA+), NEC (A-), Sanyo (BBB) and Sharp (AA+) .

(4) Four companies from the gas industry: Osaka Gas (AA+), Toho Gas (AA), Hokkaido Gas (A) and Saibu Gas (A+).

It is noted that the credit risk spreads to be assessed are shown by the differences between the spread of the highest rated company (Tokyo Gas with grade AAA) and that of each other company.

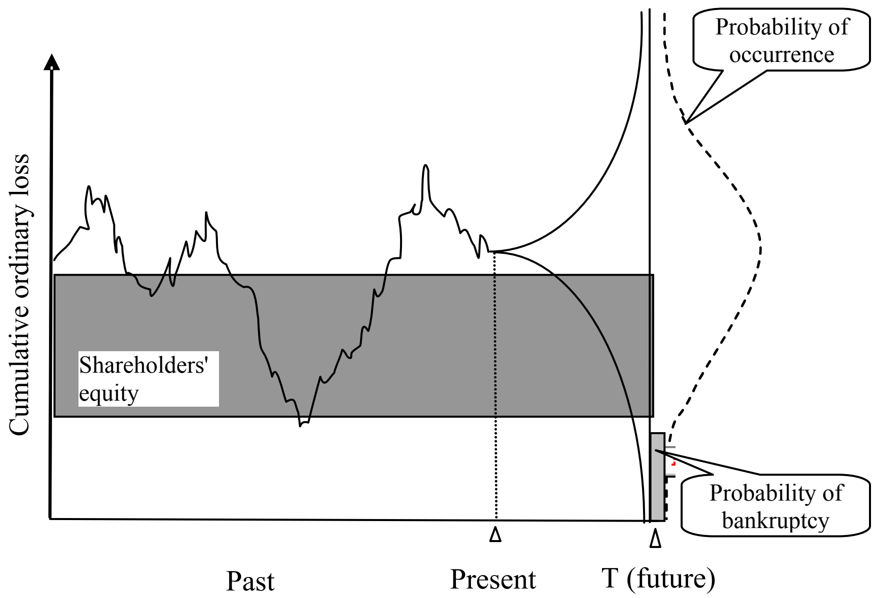

Fig. 3 Concept of proposed credit risk assessment model

Note:
1. Credit risk spread is estimated using the probability of bankruptcy (i.e. when cumulative ordinary loss becomes larger than shareholder equity).
2. Credit risk spread is directly estimated from the probability of occurrence of ordinary loss and the shareholder equity ratio.

5. Empirical Results of Our Investigation

5.1 Result from the long-term cash flow prediction model

We are in a position to report and discuss empirical results obtained from the two pillars of our grand model of credit risk assessment: the long-term cash flow prediction model and the credit risk spread assessment model. Let us begin to write down results from the first pillar, followed by the second.

We note that the total number of structural equations used for the twenty industries are approximately two hundred, with the explanatory variables being selected from Akaike Information Criterion and the value of t. The model is clearly a combination of a multiple regression model and an autoregressive model used for residual. It has been confirmed that the residual in individual structural formulae represents noise by using the Ljung-Box test (hereafter referred to as the LB test).

Table 1 summarizes the model structure used with an electric appliance industry as an example of the cash flow prediction model. The value of t used in the structural formula is high, meaning that the estimation accuracy is favourable. The profit structure of Hitachi, a major company in the industry, is also shown in the table as a good example of an individual company.

Table 1. Estimation result of cash flow prediction model (for electric appliance industry)

	Explained variable	Name of explanatory variable (1): parameter Lower line: value t	Name of explanatory variable (2): parameter Lower line: value t	Constant: parameter Lower line: value t	ρ: parameter Lower line: value t	Akaike Information Criterion Lower line: LB test
Electric appliance industry	Sales (MA, %)	Real/nominal GDP (MA):2.050193 3.515	Corporate Goods Prices (MA): 3.751	-0.003173 -0.142	0.367709 2.183	-99.02 0.040～0.454
	Cost (MA, %)	Real/nominal GDP (MA):1.892216 3.244	Corporate Goods Prices (MA): 3.92	0.003409 0.152	0.380432 2.253	-99.459 0.050～0.415
	Sales administrative expense (MA, %)	Real/nominal GDP (MA):1.823864 4.227	Corporate Goods Prices (MA): 0.823545 4.861	-0.001905 -0.097	0.59345 3.871	-126.675 0.186～0.808
	Ordinary profit rate	Operating profit rate: 1.047073 33.36	Interest of national bond: -0.001192 -2.292	-0.00594 -0.595	0.980407 41.617	-321.634 0.745～0.963
	Current profit rate	Ordinary profit rate: 0.754917 19.531	—	-0.012034 -6.022	0.472554 3.492	-365.435 0.604～0.988
	Depreciation (MA, %)	Depreciated tangible asset (MA): 12.123	—	0.012822 1.011	0.483961 3.579	-124.26 0.086～0.414
	Capital investment (MA, %)	GDP capital investment (MA): 1.355068 5.22	—	0.005439 0.145	0.136685 -0.326	-16.777 0.009～0.050
Company belonging to the electric appliance industry <Hitachi> On consolidated base	Sales (%)	Sales of electric appliance industry: 3.454	—	-0.03057 -0.708	-0.13387 -0.657	-6.412 0.618～0.998
	Cost (%)	Cost of electric appliance industry: 3.289	—	-0.03032 -0.693	-0.15655 -0.771	-5.635 0.566～0.998
	Sales administrative expense (%)	Sales administrative expense of electric appliance industry: 2.28964 4.129	—	-0.03025 -0.679	-0.05592 -0.277	-8.52 0.827～1.000
	Current profit rate	Operating profit rate of electric appliance industry: 1.16779 5.428	—	-0.02781 -3.138	0.28175 1.552	-144.99 0.132～0.976

Note:
1. BL test gives the estimated volume using the Box-Ljung test and the significance probability of the lag between the 1st and 16th terms.
2. MA gives the 2-term moving average of the current and previous fiscal years. % is the growth rate of the previous fiscal year.

Now, let us look at Figure 4. This figure indicates the operating profit and cash flow of the electric appliance industry that are calculated using the structural formulae. The estimated value (shown by a dotted line) of operating profit from 1972 to 2005 corresponds well with the actual value (indicated by a solid line). By using the same model , a ten-year prediction for fiscal 2006 to 2015 is then made, with the following two scenarios being employed. They are: (1) the benchmark scenario characterized by average 2% plus normal business cycle, which is based on the Middle-term Economic forecasts made by the NLI Research Institute; and (2) the risk scenario as a stress test. The stress test is a well established technique which uses historical data and assumes a low probability scenario in the prediction, preparing for unanticipated situations through any potential loss..

With the benchmark scenario, the operating profit is very gradually dropped, eventually to the level of fiscal 2015, namely about 1.9 trillion yen, which is a figure slightly below that of fiscal 2005.

On the other hand, with the risk scenario the assumption is made that the growth rate for the initial four years is minus 1.5% , the ten-year cumulative growth rate being zero. These low figures reflect the world-wide economic depression associated with the current financial crisis. In this case, the operating profit of the entire industry becomes negative in six years. The risk scenario allows institutional investors to use their own economic forecasts and screening capabilities: they can actually do their own qualitative assessments and explicitly change their course at each stage as they feel appropriate.

Finally, it is worthy of noting that the stress test is capable of providing prior signs of a company that may suddenly go bankrupt.

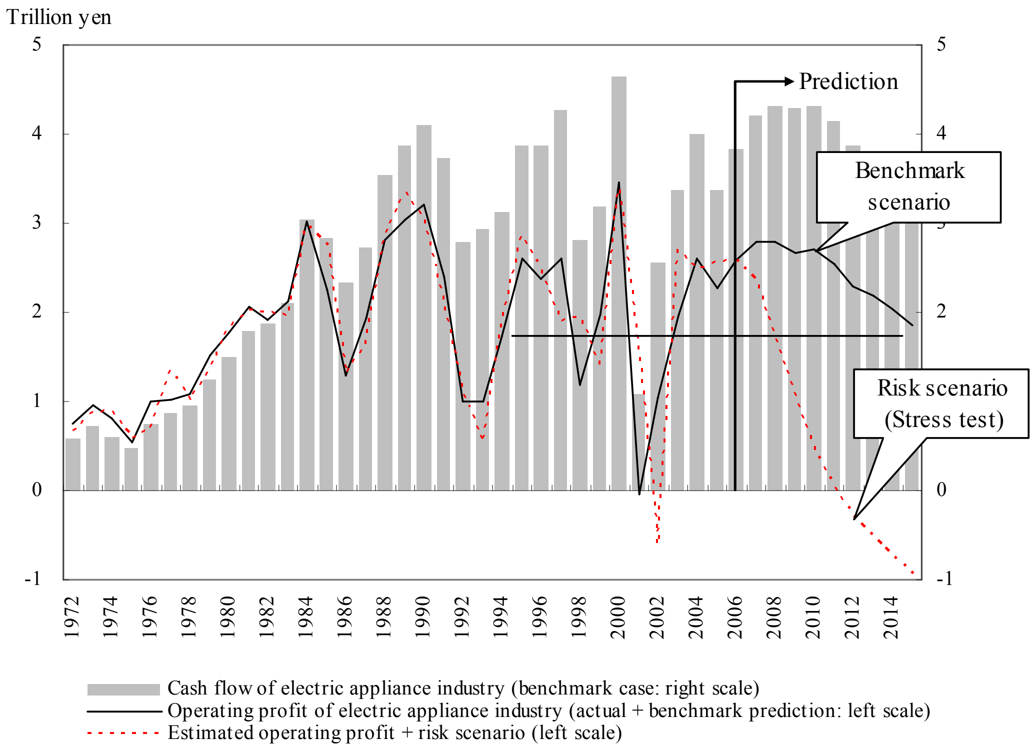

Figure 4. Prediction of operating profit and cash flow of electric appliance industry

5.2 Results from the credit risk spread assessment model

Let us carefully record empirical results obtained from the second pillar of our new grand model: the credit risk spread assessment model.

We would like to point it out that credit risk spreads over the ten year period are pooled for seventeen companies and their structures are duly analysed. It is noted that these spread are calculated on the basis of variations in market rates published by Mitsubishi UFJ Securities in January 2007, whereas the number of pooled samples is one hundred and seventy since there are seventeen companies in each of ten years.

Our empirical analysis has employed the Ordinary Least Square Method together with the Fixed Effect Model and the Random Effect Model. Note that the last effect model is selected through use of the F–test and other appropriate tests.

We have obtained the following structure formula:

Credit risk spread =

$$\underset{<9.30657>}{18.257 + 58.5069 * (\text{probability of occurrence of ordinary loss})} - \underset{<-4.70876>}{20.61238 * (\text{equity ratio})}$$

The coefficient of determination adjusted for the degree of freedom is 0.573. The t- values of t in the two explanatory variables, which are given within < > in the above formula, are very high since they are respectively 9.30657 and - 4.70876. Therefore we believe that our model represents reasonably well the credit risk structure under investigation.

6 Discussions and concluding remarks

We are now ready to give comprehensive discussions on our new grand model of credit risk assessment, which may lead us to make concluding remarks for future research.

Figure 5 summarizes the results of analyzing our credit risk spread model by each company and each period. While small spreads are revealed for highly rated companies such as Osaka Gas, Nippon Steel and Hitachi, larger spreads exist over longer periods for the same company. This clearly indicates the theoretical consistency of the estimated results.

On the other hand, the estimated values markedly differ from the actual values in two areas. Let us look at the bar graph in Figure 5. In one area, the estimated values of spreads for highly rated leading companies are considerably smaller than their actual values, whereas in the other, the differences between the actual values and the estimated values become larger for a longer period.

To take one example, Nippon Steel has wide fluctuations in ordinary profit with its financial structure where cumulative current account deficits tend to undermine the value of its shareholder equity. While the estimated spread for the ten year period is thirty-five basis points (hereinafter referred to as bp), the market spread is only six bp, implying that the difference between the two spreads is almost as big as thirty bp. Such a trend becomes even more apparent as the number of periods increases, thus suggesting that a number of elements other than the financial structure can influence credit risk assessment. In fact, it is a rather easy job to see that in the market place, the brand image may be overvalued and the long-term credit risk undervalued.

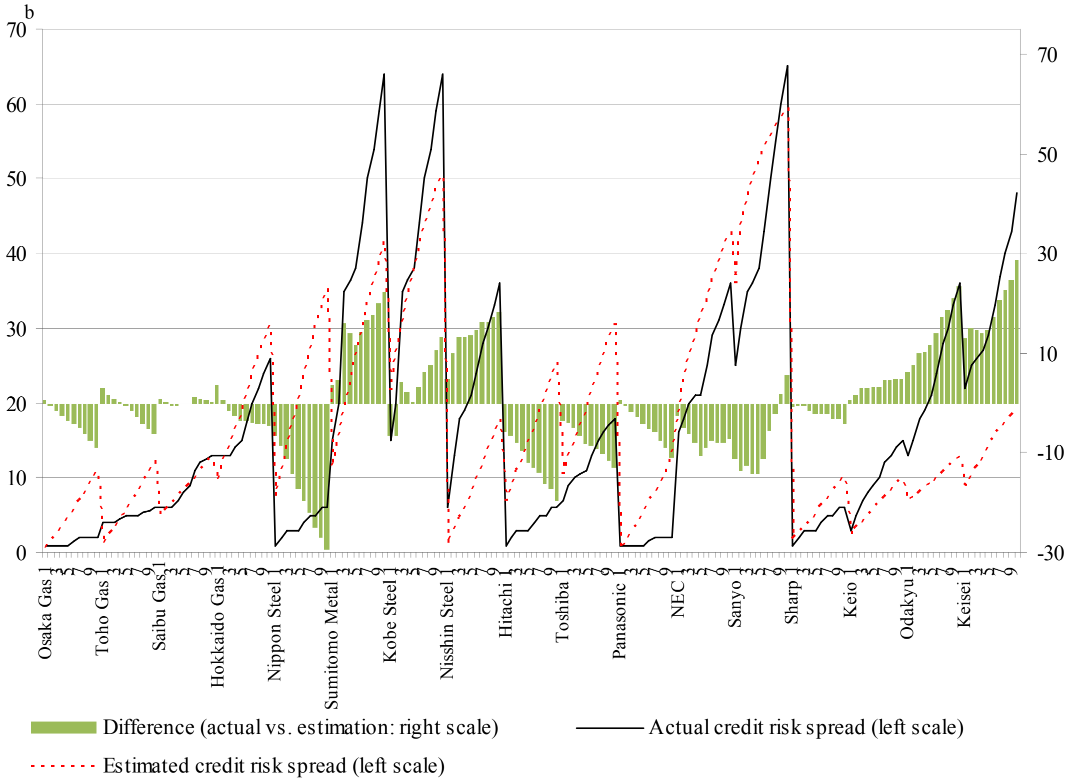

Fig. 5 Estimation of credit risk spread by period

Credit spreads are then separately estimated for a group of leading companies and another group. As revealed in the estimation results given in Table 2, the t-values of for the explanatory variables are all significantly high in terms of the significance level of one percent. The parameter for the probability of ordinary loss occurrence for the group of leading companies is 12.0168, which is about one fourth of the other group. This certainly indicates that a one percent increase in the probability of ordinary loss occurrence would only increase the market spread by twelve bp for the group of leading companies but as much as forty-seven bp for the other group. This is presumably because leading companies facing risks have many intangible capabilities such as stronger brand appeal, and also because a certain amount of public funds are more likely to be injected in the case of emergency.

In connection with market spreads, ratings are apt to be comprehensively determined in consideration of a variety of elements, not only the financial structure factors. There exist many cases, however, in which the rating of companies on the verge of bankruptcy does not necessarily get downgraded. A reasonable view of the situation made in ordinary times would not be so reasonable when everything changes all of sudden and a company begins to draw scepticism from the market. The market sometimes tends to overvalues elements other than the financial structure and to yield a too small spread for highly rated companies, particularly with respect to long term credit risk assessment; which would more or less result in a sort of rating bias..

While institutional investors mostly use ratings as a source of qualitative assessments, it is also important to conduct credit risk assessments which rather focus on quantitative assessments. Hopefully, consideration of both quantitative and qualitative assessments would make our new grand model more instructive than otherwise in credit risk assessment.

.Table 2 List of parameters in credit risk spread models

	Total		Leading companies (40 samples)		Other companies (130 samples)	
	Parameter	Value t	Parameter	Value t	Parameter	Value t
Probability of occurrence of ordinary loss	58.5069	9.30657	12.0168	10.2892	47.3271	5.38282
Capital adequacy ratio	-20.6138	-4.70876	-2.84492	-3.89968	-49.2053	-7.64111
Constant term	18.257	4.56082	3.0148	5.36571	41.1263	7.38488
Adjusted determination coefficient	0.573118		0.868654		0.456828	

Note:

1. The Random Effects Model was selected from 3 panel analysis models.
2. A present value rate of 7% was applied to the adjustment because the capital adequacy ratio decreases its securing effect as the number of periods increases.
3. Four companies were chosen as leading companies: Osaka Gas, Nippon Steel, Hitachi and Panasonic.

Bankruptcy rates obtained using option models are sensitive to the influence of stock prices, and contain a number of problems that include the necessity for additional models with enhanced hypotheses. The long-term credit risk assessment model proposed in this paper distinguishes itself from other works in that it does not explicitly make use of stock prices. Although it may require some time span for effective use of the model, the final results are expected to be highly stable and trustful. Furthermore, it would appear to provide even more satisfaction, especially when we assess long-term credit risk. This is because the qualitative assessment model for institutional investors together with and the stress test can also be incorporated into the model when we are at the stage of predicting the cash flow of a certain company.

In general, institutional investors are required to eliminate rating biases and establish their own criterion for credit risk assessments through using their own quantitative models. In order to promote our research furthermore, we wish to increase the number of companies to be analyzed and thereby to enhance the reliability of our grand model of credit risk assessment. This problem will be left for future research.

References

Crook and Banasil (2004) "Does Reject Inference Really Improve the Performance of Application Scoring Models ? " *Journal of Banking & Finance* 28 (4), 857-74.

Dietsch, Michel and Petey, Joel (2002) "The Credit Risk in SME Loana Portfolios, Modeling Issues, and Pricing and Capital Requirements." *Jouurnal of Banking and Finance*, 26, 303-22.

Duffie and Lando (2001) "Term Structures of Credit Spreads with Incomplete Accounting Information " *Econometrica*, 69, 633-64.

Hasumi, Ryo and Hideaki Hirata（2008）" Credit Scoring and Bank Management: Verification by Using a 1st Generation SME Credit Risk Measurement Model " *JCER Discussion Paper* No.116, 1-27.

Hideaki Hirata (2005) " Recent Development of Japanese SME Finance" *Keiei Shirin* Vol42, No.2, 31-51.

Hideya Kubo (2008）"Credit risk evaluation for institutional investors―The proposal of the cash flow projection model which utilized the macro model" J*ournal of Risk Research*、Vol.18, No.1, 97-104.

Hideya Kubo（2008）"The proposal of the credit risk spread valuation model which computes loan price " *The Hione Ronso*, No.374, 181-99.

Kazuyuki Suda and Hitoshi Takehara（2003）" Empirical study of a free cash flow model and a residual-profits model", Database of Tukuba University, 1-21.

Kijima, M. and K. Komoribayashi (1998) "A Markov Chain Model for Valuing Credit Risk Derivatives" *Journal of Derivatives*, Fall 1998, 97-108.

Marumo Kouhei, Ieda Akira (2001) "The pricing method using the cox process of the financial product with a credit risk" *Monetary and Economic Studies*, Vol.20, No.1, 19-47.

Shin Kaneya、Hideaki Hirata, Kenji Nishizaki (2003) "Default stochastic model revisit" *Bank of Japan Working paper series* No.03-J-2, 1-39.

Takao Kobayashi (2003) "Credit Risk Modeling Approaches " *CIRJE Discussion Paper J series*，CIRJE-J100, 1-30.

Yasushi Toyoda and Ono takahiro,（2005）"Risk Measure of Credit Portfolio with Reduced-Form Model of Credit Risk" Japan Association for Management Systems, research presentation report data , 1-2.

Zhou (2001) "The Term Structures of Credit Spreads with Jump Risk" J*ournal of Banking and Finance*, 25, 2015-40.

Bank of Japan (2004) The enforcement plan 2004, http://www.boj.or.jp/type/pub/pb_geppo/kako03/giji04039.htm

Ministry of finance, Policy Research Institute （2006）Financial Statements Statistics of Corporations by Industry, http://www.mof.go.jp/1c002.htm

NLI Research Institute （2006）Middle-term Economic forecasts, http://www.nli-research.co.jp/report/econo_letter/2006/chuki0610.html