Comparative study of credit rating of SMEs based on AHP and KMV model

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Abstract. This paper constructs credit rating model for small and medium-sized enterprises (SMEs) by the comparison of Analytic Hierarchy Process (AHP) and the modified KMV model (Or called KMV-Merton model). Mainly based on the analysis of financial situation, stock price and other related data in printing industry in listed company in 2012-2014, we compare the differences between the two theories in credit rating, verify the data rationality, broaden the thought of result reliability and explore how to strengthen the SEMs credit rating system in our country. The research will have certain help on enhancing the credit rating management.

1. Introduction

Nowadays, they are faced with the issues of finance channels narrow, difficulty in recovering account receivable in SMEs, which are resulted in bad debt losses in our country. Due to small scale, limited strength, capital return unsmooth, SMEs are difficult to Market-based financing by the bond or stock. Many economists believe bank loan is an important channel for SMEs to obtain external funding. However, because of lacking an effective credit rating system currently, SMEs are often hard to reach the bank lending criteria and to get the bank's loan. In some extent, these will constrain the SMEs' development, and also have some influence in the overall development of the national economy [1].

2. Literature Review

Credit rating, a social service agency, provides credit status to the society. There are many ways in foreign credit rating which can be divided into three classes. The first class is called the expert systems, such as 5C principles, 5W, and 5P, prevailed in 1950s. The second class is called the statistical systems, such as multivariate linear discriminant analysis model, the second DA model, linear probability model, logit model, KMV model, etc. The third class is known as AHP. Many Chinese scholars also study SMEs' credit management in different views. For example, Li Li-qun (2004) believes that "non-financial factors analysis" is an important part in the credit decision. Jiang Ling-min (2006) raises that financial quantitative analysis factors model could solve too subjective questions in non-financial factors from three respects of industry, operation and management risk [2]. Wu Rui-dong (2007) states that we should also consider building the entire tax credit system with a broader view in tax credit [3].

3. The basic principle of AHP and KMV model

3.1 The basic principle of AHP

In the early 1970s, AHP was put forward by Thomas L. Saaty who is an American operational research professor, which was multilayer weighty analytical method with multi-object, multi-rule and so on. The method is simultaneously based on qualitative and quantitative factors, and provides basis judgment comparative matrixes for decision [4]. Application of AHP to a decision problem involves four steps. Step 1 is to model the problem as a hierarchy. An AHP hierarchy consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. Step 2 is to make pairwise comparisons. The pairwise comparisons from each branch at each level of the hierarchy are entered into a matrix and used to determine a vector of priority weights. Step 3 is to check the consistency of the judgments. If judgment matrix is not exactly the same, the judgment matrix's eigenvalues will change correspondingly, the rest characteristic root negative average is introduced into the methods, as a measure of the consistency of judgment matrix deviation, named as index Consistency Index (CI). CI= (λmax –n)/ (n-1). λmax is the most latent root of judge matrix, n is the order of judge matrix. The greater value of CI, the greater degree on judgment matrix deviate consistent level entirely. Index Random Index (RI) values are shown in Table 1.

Table 1. The average consistencies of random matrices

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.52

The consistency of the judgmental matrix can be determined by a measure called the consistency ratio (CR). In general, a consistency ratio of 0.10 or less is considered acceptable. If the value is higher, the judgments may not be reliable and have to be elicited again. Step 4 is come to a final decision based on the results of this process. We can confirm the weightiness of all factors in each level to the all target; thereby we can make the selection.

3.2 The basic principle of KMV model

KMV model is one method that the credit risk of loans is determined by the debtor's asset market value if liability is given. But assets don't really exist in the market transactions, the market value of the company's assets can't be directly observed. Therefore, the model will transfer the view of the bank's loans, considering the issue of the borrower themselves repaying the loan.

Ma Ruo-wei (2006) [5] select 852 listed companies in china to study the applicability of KMV in our country. Through the empirical research, he thinks that KMV is feasible in the early warning of the financial distress for our listed companies. KMV doesn't require efficient market hypothesis. Capital of China's securities market is weak because of being influenced by speculate and "insider information", it will lead to sharp fluctuations in share prices. So KMV is one of the most useful credit risk rating models and its steps are as followings, firstly, by using the Black-Scholes option pricing formula, based on the asset market value, the volatility of the company's equity, the debt expiration time, the risk-free interest rates and the book value of liabilities, it could estimate the market value of the company's assets and the volatility of the asset value. Secondly, according to the value of company's liabilities, it can calculate the company's default points (DP) and the distance to default (DD). The last one, On the basis of the relationship between the DD and the expected default frequency (EDF), It can convert DD to the probability of default. [6].

4. Analysis of AHP and KMV model

4.1 Enterprise Profile

Company Name: Tungkong Co., Ltd. (hereinafter: TUNGKONG); Enterprises Registered Capital: RMB 364 million; It was listed in Shenzhen Stock Exchange on 2nd Mar 2007 (Stock Code: 002117). The company has become a comprehensive enterprise group, which covers ticket and security printing, label printing, data processing, smart card converting, and R&D.

4.2 The application of AHP to construct SMEs credit rating system

Based on the characteristics in SEMs and the definition in the file of "The SMEs Standard Code" No. 300, 2011 issued by the Ministry of Industry and Information Technology of the P.R of China, this paper is trying to build SMEs credit rating system. The goal level A are divided into quantitative Indicators and qualitative Indicators. The criteria level are solvency indicators A_1, profitability indicators A_2, operational capacity indicators A_3, business growth indicators A_4, enterprises basic qualityA_5, enterprises comprehensive quality A_6. The corresponding alternatives level are quick ratio B_1, current ratio B_{12}, asset-liability ratio B_{13}, interest coverage ratio B_{14}, return on equity B_{21}, return on total assets B_{22}, sales profit B_{23}, current asset turnover B_{31} inventory turnover B_{32}, account receivable turnover B_{33}, sales growth rateB_{41}, net profit growth rateB_{42}, net asset growth rate B_{43}, enterprises scale B_{51}, leadership qualities B_{52}, management level B_{53}, social influence reputationB_{61}, industry prospects and B_{62} and external environment B_{63}.

By using AHP to calculate these indexes and judge their rational, firstly, we construct A-A_1, A_2, A_3, A_4 judgment matrix, as shown in Table 2.

Table 2. A-Ai (A-A_1, A_2, A_3, A_4)

A	A_1	A_2	A_3	A_4	Wi(weighting value)
A_1	1	3	3	2	0.4550
A_2	1/3	1	1	1/2	0.1411
A_3	1/3	1	1	1/2	0.1411
A_4	1/2	2	2	1	0.2627

Secondly, calculate the maximum eigenvalue of matrix, name as λmax = 4.0104; thirdly, the consistency test: CI= (4.0104-4) / (4-1) = 0.0035, as known RI (4) =0.9, CR=0.035/0.9=0.0038<0.1. Similarly, matrix A_1-B_{1i} (A_1-B_{11}, B_{12}, B_{13}, B_{14}), wherein, λmax=4.2188, CI=0.0729, CR=0.0810<0.1, by consistency test; matrix A_2-B_{2i} (A_2-B_{21}, B_{22}, B_{23}), wherein, λmax=3.0183, CI=0.0091, CR=0.0158<0.1, by the consistency test; matrix A_3-B_{3i} (A_3-B_{31}, B_{32}, B_{33}), wherein, λmax=3.0000, CI=0, CR=0<0.1, by consistency test; matrix A_4-B_{4i} (A_4-B_{41}, B_{42}, B_{43}) which, λmax=3.0385, CI=0.0193, CR=0.0332<0.1, by consistency test. We can also use the same way to matrix A_5-B_{5i} (A_5-B_{51}, B_{52}, B_{53}) and A_6-B_{6i} (A_6-B_{61}, B_{62}, B_{63}). They are proved that it is reasonable to use the credit rating index of AHP. Thus, we can calculate the weight of matrix A-$B_{1i}B_{2i}B_{3i}B_{4i}$ and matrix A-B_{5i} as following, B_{11}=0.0485; B_{12}=0.2631; B_{13}=0.1220; B_{14}=0.0214; B_{21}=0.0337; B_{22}=0.0882; B_{23}=0.0193; B_{31}=0.0706; B_{32}=0.0353; B_{33}=0.0353; B_{41}=0.0275; B_{42}=0.1673; B_{43}=0.0679; B_{51}=0.3559; B_{52}=0.4294; B_{53}=0.1080; B_{61}=0.1009; B_{62}=0.1904; B_{63}=0.2019.

Then, we make the calculation of the quantitative and qualitative indicators. According to the company's financial data (Source: Sina Finance and Wind Information) in 2012-2014, Generally speaking, we should take the data on business operation in three consecutive years, since only one year's information is not smooth enough. For the calculation of the quantitative indicators in TUNGKONG, firstly, we can use the formula (1) to calculate the actual value.

$$X = 0.5X_1 + 0.3X_2 + 0.2X_3 \qquad (1)$$

Based on the standard definition of SMEs, this paper select 7 printing industry sample of listed companies, as bellows: JINJIA (code: 002191); HONGBO (code: 002229); DONGFENG (code: 601515); JIELONG (code: 600836); SHENGTONG (Code: 002599); JINYE(code: 000812); TUNGKONG (code: 002117), select the financial data which published in 2012-2014 annual reported, and calculate separately for each evaluation of the actual value; We define the industry indicators optimum value as 100 points and the average as 60 points. Then we can calculate the value of quantitative indicators as follow formula (2):

$$\text{Indicators Score}=100-40\times\frac{\text{Industry Indicators Optimum Value}-\text{Company's Indicators Actual Value}}{\text{Industry Indicators Optimum Value}-\text{Industry indicators average value}}. \quad (2)$$

For the value of qualitative indicators, by DaGong Global Credit Rating Co., Ltd about the domestic printing industry's credit rating index score. We can obtain the TUNGKONG's credit rating score in AHP as Table 3.

Table 3. TUNGKONG's credit rating score in AHP

Goal	Criteria	Alternatives	Indicator Score	Weight	Final Score
Quantitative Indicators	Solvency Indicators A_1	Quick ratio B_{11}	93.02	0.0485	4.51
		Current ratio B_{12}	50.00	0.2631	13.16
		Asset-liability ratio B_{13}	46.87	0.1220	5.72
		Interest coverage ratio B_{14}	21.70	0.0214	0.46
	Profitability Indicators A_2	Return on equity B_{21}	62.68	0.0337	2.11
		Return on total assets B_{22}	100.00	0.0882	8.82
		Sales profit B_{23}	74.11	0.0193	1.43
	Operational capacity Indicators A_3	Current asset turnover B_{31}	75.25	0.0706	5.31
		Inventory turnover B_{32}	92.86	0.0353	3.28
		Account receivable turnover B_{33}	100.00	0.0353	3.53
	Business growth capacity Indicators A_4	Sales growth rateB_{41}	66.76	0.0275	1.84
		Net profit growth rateB_{42}	69.73	0.1673	11.67
		Net asset growth rate B_{43}	56.82	0.0679	3.86
Qualitative indicators	Enterprises basic qualityA_5	Enterprises scale B_{51}	25.16	0.3559	8.95
		Leadership qualities B_{52}	15.32	0.4294	6.58
		Management level B_{53}	19.88	0.1080	2.15
	Enterprises comprehensive qualityA_6	Social influence reputation B_{61}	15.62	0.1009	1.58
		Industry prospects B_{62}	5.22	0.1904	0.99
		External environment B_{63}	5.12	0.2019	1.03

We can be noticed that TUNGKONG is calculated as a score of 86.98, A grade according to the following table 4 by SEMs credit rating Standard.

Table 4 SEMs credit rating Standard

Level	A+	A	A-	B+	B-
scores	91-100	81-90	71-80	61-70	<60
definition	excellent	good	general	bad	worst

4.3 The application of KMV model to construct SMEs credit rating system

In this paper, with the actual condition of SMEs in listed companies, we amend the calculation of stock value and DP in the model. We make parameters setting as bellows, V_A is defined as the company's assets. V_A =the number of tradable shares× market price +the number of non-tradable shares× (market price ×22%) [7]. The market value of non-circulating shares=the number of non-circulating shares ×net asset value per share; The market value of circulating shares=the number of circulating shares ×the annual average closing price; The annual average closing price=the total of all transactions closing price in one year/ transaction days; DD is defined as distance to default.

DD= $(V_A$-DP)/$V_A\sigma_A$; Default point (DP) = current liabilities + 50% of the long-term liabilities; σ_A is standing for enterprise asset value volatility; r is standing for risk-free interest rate, i.e. bank deposit interest rate of 3.00% on the same period; T is standing for the debt maturity.in this paper, we select a year for debt maturity.$\sigma_E = \sigma'_E\sqrt{T}$,$\sigma_E$ is the annual volatility of the stock; σ'_E is the day volatility of the stock.

Based on stock prices in 7 samples, we can calculate market capitalization, the daily volatility and the annual volatility by use of EXCEL. On the basis of financial data, we can obtain samples' DP, and then we can calculate the value of V_A,σ_A, EDF by using MATLAB 7.0 as shown in Table 5.

Table 5. DD and EDF in 7 samples (RMB Yuan)

Stock code	Listed company	V_A	σ_A	DD	EDF
002191	JINJIA	1.0436E+10	0.34187	2.6312	0.004254
002229	HONGBO	3.8868E+09	0.51780	1.7047	0.044125
601515	DONGFENG	3.7689E+09	0.62048	1.2618	0.103510
600836	JIELONG	5.6125E+09	0.21127	2.7363	0.003107
002599	SHENGTONG	1.7495E+09	0.33777	2.1616	0.015323
000812	JINYE	3.2557E+09	0.38393	2.0952	0.018077
002117	TUNGKONG	7.0507E+09	0.51320	1.8263	0.033902

Thus, the greater on DD's value, the higher of company's ability to control debt. Then the company can repay the debt on due day, and thus the possibility of default will be greatly reduced with a better credit conditions; oppositely, the lower of company's ability to control debt. There are more serious on debt crisis and the possibility of bankruptcy, and thus the company has the bad credit status itself. In "EDF & External Rating Index", TUNGKONG is referred to B grade.

4.4 Comparative analysis of AHP and KMV

In this paper, TUNGKONG's credit rating is A level in AHP, while, B grade in KMV model. The reason is mainly the following aspects:
Firstly, the methods of AHP is full of subjective, it can be well combined with a qualitative and quantitative analysis and easy to make technically. However, the selection of the index weight has

some subjective. In the respect of calculating the weight index, AHP hasn't taken all the indicators into account; it only considers the relative importance indicators, which may lead to some errors. Secondly, KMV model states many premises and assumptions, which have some discrepancies in the listed companies. Although KMV overcomes weaknesses of the indicators' subjectivity, there are some shortcomings. Firstly, based on the assumption of normal distribution, the model can't judge different types of debts. It assumes that the stock price is a random process, and assets value is subject to the normal distribution. While in reality, stock prices are tending to be made by market environment. Secondly, the factors of small scope of the model and the unreasonable assumption for debt structure will affect the result. Generally, it is applicable to risk assessment in listed companies, but is not suitable for non-listed companies. Finally, the expected default rate reflects the expected probability of default, rather than the actual probability of default, which is a simulated historical data indicator. Thirdly, KMV is simpler than AHP, which doesn't consider all factors in industry.

5. Summary

They play an important role in Chinese economic construction for SMEs. However, the current economic factors, political system, and characteristics of SMEs themselves, all which hinder sustainable development in SMEs. The current rating system are more suitable in large enterprises, if we use these methods, they will bring the SMEs credit rating inapplicable and unfair. So I believe, Firstly, although there are many shortcomings in making KMV in China's listed SMEs, on the credit evaluation risks, KMV are slightly better than by AHP. KMV is easier to be operated, and its samples' data is easy to get, and its mathematical principles and methods are easy to understand. If we gain the corresponding financial value and stock price, it can to be performed step by step. In the scope, KMV can be applied to other listed companies, while AHP can be applied to China's SMEs. Secondly, Regardless of whether AHP or KMV, their means are using all kinds of fundamental financial information. The current system of financial report published in listed company isn't perfect. As for SMEs, if we further strengthen information disclosure, there are more financial or even overall indexes serving in AHP. For KMV model, there will have more comprehensive information in capital market, hereby they will play a positive role on stabilizing stock price and making credit risk. All these can make the KMV model and AHP a wider range of application, which need to be further research.

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