Research on the Credit Risk of Small and Medium Enterprises for Commercial Banks---Based on FAHP Method

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Abstract: *With the increasing loans issued to the small and medium-sized enterprises, commercial banks pay more attention to control credit risk. Compared with qualitative analysis，quantitative analysis is of great benefit for commercial banks to build a system of risk management. Fuzzy Analytic Hierarchy Process (FAHP) will combine qualitative analysis with quantitative analysis. FAHP ensures the weights scientific and reasonable. The result of quantizing credit risks make clear that commercial banks should focus on the personal evaluation of business owners and the enterprise operation environment involving in SMEs, which is different from the large and medium-size enterprises.*

Keywords: *The Small and medium-sized enterprises (SMEs); Credit risks; Fuzzy Analytic Hierarchy Process (FAHP); Effect weight. At present the commercial bank credit is still the main financing way for the small and medium-sized enterprises（SMEs）in China. At the same time, loan business issued to SMEs has become an important market to expand for Chinese commercial banks. It is the main factor for commercial banks to maintain a competitive advantage in the credit market whether the credit market of SMEs is developed successfully or not. As a result of this, it is necessary for commercial banks to avoid credit risks coming from SMEs. Not only difficult financing of SMEs would be solved, but the commercial banks expand their market too.*

1. INTRODUCTION

According to the Chinese Banking Regulatory Commission (CBRC), by end of June 2012, the SMEs' rate of non-performing loans stands at 2.4%. During the same period it is much higher than 0.9%, that is, the whole banking non-performing loan ratio level. The SMEs' credit risk is rather high. It is urgent to research how to avoid the credit risk with most of the commercial banks paying more attention to credit business in China. Traditionally, commercial banks in China mainly control credit risk by qualitative analysis to identify various risks. In contrast, quantitative analysis methods are rarely applied in China. In addition, the commercial banks mainly analyze

the borrowers' financial information before they grant loans, lack of attention to non-financial information.

Generally speaking, it is a common phenomenon that the SMEs' financial information is not true enough and the information is not transparent as well. On the contrary, non-financial information has a profound influence on the loan business, which leads to the pre-work of loan inefficient. It is inevitable to make things difficult when the commercial banks measure credit risk in pre-loan stage.

2. LITERATURE REVIEW

Before the 1970's ,when evaluating SMEs' credit risks, the commercial banks laid emphasis up on quantitative analysis, such as financial statements and static financial data. Until the 1990's, the traditional monetary data analysis was replaced by dynamic econometric analysis method which adopted modern credit risk analysis. Built on multiple regression, Joes.A. Gaptista（2006 analyzed the influence factors of SMEs' credit risk. The simulation results showed that factors affecting the risk of SMEs' loans included business philosophy, management level, having illegal record or not and loan interest rate and purpose, etc. Johan and Afore(2007) , the professors of the University of Massachusetts, analyzed thoroughly the cases of SMEs' loan in India. They concluded that the influencing factors of credit risks are composed of credit conditions, household income and outlay, level of education and total fixed assets of the borrowers. Legally binding force on the borrowers was a necessary factor, too.

Compared with western countries, the scholars in China mainly focused on empirical study of

SMEs' credit risk. The quantitative analysis often adopted the data envelopment analysis（DEA）

and analytic hierarchy process (AHP).As far as SMEs is concerned, the research on credit risk pay more attention to qualitative analysis, which is limited and further study is required. In addition, subjective evaluation is not conducive to building a mature analysis model of credit risk. Based on the reasons for financing difficulty, Dajing Z and Bo Z (2009) presented that it is the key to establish a complete and feasible credit rating system to solve the problem of financing difficulties for SMEs. Zhenwu X (2008) expounded the characteristics of credit rating on SMEs. Combining quantitative indexes and qualitative indexes, he built the indicators system and determined the index weights by analytic hierarchy process. Nonetheless, his research was lack of concrete utilization and experimental analyses.

Fuzzy Analytic Hierarchy Process (FAHP) combines qualitative analysis with quantitative analysis. Both expert experience and mathematical methods are considered which ensures the weights scientific and reasonable. Quantizing credit risks becomes feasible. Commercial banks easily establish reasonable evaluation system of small and medium-sized enterprises.

3. BUILDING SMES' INFLUENCE FACTORS OF CREDIT RISK

There are numerous factors that will influence credit risk of small and medium-sized enterprises, such as financial situation, the economic cycle, industry development, the international economic environment. Build on the current research results, the paper will build the system that affects SMEs' credit risk through analyzing the characteristics. It is a benefit for the commercial banks control risks. We only chooses the limited five kinds of A-level indicators which affect the credit risks directly. Furthermore, A-level indicators will be decomposed three B-level indicators to analysis and measure thoroughly. The system that affects SMEs' credit risk is as Table1.

Table1. *Influencing factors of SMEs' credit risk*

The first grade		The second grade
A_1	corporate balance sheets	solvency(B_{11})
		profitability(B_{12})
		development ability(B_{13})
A_2	enterprise management status	development sustainability(B_{21})
		credit status(B_{22})
		innovation capability(B_{23})
A_3	enterprises operating environment	economic policy （B_{31}）
		prospect of the industry （B_{32}）
		market share （B_{33}）
A_4	credit guarantee way	mortgage （B_{41}）
		pledge （B_{42}）
		third-party guarantee （B_{43}）
A_5	business owners status	personal finances (B_{51})
		personal credit status(B_{52})
		level of enterprise management(B_{53})

4. ANALYZING INFLUENCE DEGREE OF THE SMEs' CREDIT RISKS FACTORS—BASED ON FAHP

The influence degree of the SMEs' credit risks factors include credit guarantee modes, the SMEs' operation, etc. We apply FAHP to analyzing credit risks factors statistically to obtain the effective weight of each factor for the commercial banks. Accordingly, the effective weight is related to the contribution degree that is important for the commercial banks to manage risks with clear target.

The influencing factors of SMEs' credit risks, involved in this article, refers to the enterprises of credit guarantee modes and the status of the business owners. The influence weights of credit risk means that the factors are different from each other. For small and medium-sized enterprises, credit risk identification is based on analysis of all factors of influence. According to credit risk weighting, and then we determine the contribution of each affecting factor.

4.1. Building Precedence Relation Matrix

Fuzzy Analytic Hierarchy Process determines weights of the risk indexes. The method is easy to follow and rather practical, despite the fact that the human factor has definite influences on the final result. To an extent, the method can overcome the weakness of AHP and broaden the range of utilization. Fuzziness lays in judging the identity of the matrix. According to fuzzy phenomenon, experts construct the fuzzy judging matrix from different angles and in different ways. In summary, there are the following three types. Firstly, membership degree r_{ij} can be replace by a_{ij} forming complementary fuzzy consistency matrix. Secondly, Triangular fuzzy number (1, m, n) takes the place of a_{ij}, which forms a triangular fuzzy number matrix characterized by reciprocal or complementary relationship. Thirdly, A_{ij} is supplanted with the interval number[a_{ij}- , a_{ij}+] ,and interval number reciprocal judgment matrix is generated.

Precedence relation matrix, $G = | g_{ij} |_{n \times n}$, is a comparison value matrix in the finite case $u = \{u_1, u_2,..., u_n\}$. The matrix involved in the paper is a kind of three-value matrix (0, 0.5, 1). It is convenient for the policy makers to judge and compare the importance. As is presented in Table2.

Table2. *Three-value matrix*

g_{ij}	importance degree
0	u_j is more important than u_i
0.5	u_j is important as u_i
1	u_i is more important than u_j

The judgments of priority among the indexes are based on the expert interview combining with the results of relevant literature. Five first grade indexes of precedence relation matrix is G_A. According to $G=|g_{ij}|_{n\times n}$, we get $r_{i=}\sum g_{ik}$ through calculating the sum by the row. The value interval of k is taken in [1,……, n].

		A_1	A_2	A_3	A_4	A_5	r_i
	A_1	0.5	1	0	0	0	1.5
	A_2	0	0.5	0	0	0	0.5
$G_A =$	A_3	1	1	0.5	1	0	3.5
	A_4	1	1	0	0.5	0	2.5
	A_5	1	1	1	1	0.5	4.5

Fig1. *The precedence relation matrix of the first grade indexes*

Accordingly, the precedence relation can be ranked as the following: business owners status（ A_5 ）> enterprises operating environment (A_3) > credit guarantee way (A_4) >corporate balance sheets (A_1) > enterprise management status (A_2).

Similarly, the index of A_1（corporate balance sheets）can be decomposed into three secondary grade indexes, which composes a new precedence relation matrix-- G_{A1}. The precedence relation can be ranked as the following: B_{11}（solvency）> B_{12}（profitability）>B_{13}（development ability）.

		B_{11}	B_{12}	B_{13}	r_i
	B_{11}	0.5	0	0	0.5
$G_{A1} =$	B_{12}	1	0.5	1	2.5
	B_{13}	1	0	0.5	1.5

Fig2. *The precedence relation matrix of secondary grade indexes subordinated A_1*

The index of A_2（enterprise management status）can be decomposed into three secondary grade indexes, which composes a new precedence relation matrix-- G_{A2}. The precedence relation can be ranked as the following: B_{22}（credit status）> B_{23}（innovation capability）>B_{21}（development sustainability）.

		B_{21}	B_{22}	B_{23}	r_i
	B_{21}	0.5	0	0	0.5
$G_{A2} =$	B_{22}	1	0.5	1	2.5
	B_{23}	1	0	0.5	1.5

Fig4. *The precedence relation matrix of secondary grade indexes subordinated A_2*

The index of A_3（enterprises operating environment）can be decomposed into three secondary grade indexes, which composes a new precedence relation matrix-- G_{A3}. The precedence relation can be ranked as the following: B_{33}（market share）> B_{31}（economic policy） >B_{32}（prospect of the industry）.

$G_{A3} =$		B_{31}	B_{32}	B_{33}	r_i
	B_{31}	0.5	1	0	1.5
	B_{32}	0	0.5	0	0.5
	B_{33}	1	1	0.5	2.5

Fig4. *The precedence relation matrix of secondary grade indexes subordinated A₃*

The index of A_4（e credit guarantee way）can be decomposed into three secondary grade indexes, which composes a new precedence relation matrix-- G_{A4}. The precedence relation can be ranked as the following: B_{42}（pledge）$>B_{41}$（mortgage）$> B_{43}$（third-party guarantee）.

$G_{A4} =$		B_{41}	B_{42}	B_{43}	r_i
	B_{41}	0.5	0	1	1.5
	B_{42}	1	0.5	1	2.5
	B_{43}	0	0	0.5	0.5

Fig5. *The precedence relation matrix of secondary grade indexes subordinated A₄*

The index of A_5（business owners status）can be decomposed into three secondary grade indexes, which composes a new precedence relation matrix-- G_{A5}. The precedence relation can be ranked as the following: B_{52}（personal credit status $> B_{51}$ (personal finances) $> B_{53}$ (level of enterprise management).

$G_{A5} =$		B_{51}	B_{52}	B_{53}	r_i
	B_{51}	0.5	0	1	1.5
	B_{52}	1	0.5	1	2.5
	B_{53}	0	0	0.5	0.5

Fig6. *The precedence relation matrix of secondary grade indexes subordinated A₅*

4.2. Calculating Fuzzy Judgment Matrix and the Weight Grade by Grade

According to the formula

$$hij=(ri-rj)/2n+0.5 \tag{4.1}$$

$$w_i= \bar{h_i} \Big/ \sum_{i=1}^{m} \bar{h_i} \tag{4.2}$$

$$\bar{h_\iota} = \sqrt[n]{\prod_{j=1}^{n} h_{ij}} \tag{4.3}$$

According to the former formulas, we can calculate the fuzzy judgment matrix and the weight of the factors belonging to sub goals.

The data of A grade can be calculated as the following.

$\overline{h_{A1}} = 0.372792,\ \overline{h_{A2}} = 0.260517,\ \overline{h_{A3}} = 0.582739,\ \overline{h_{A4}} = 0.478939,\ \overline{h_{A5}} = 0.685347.$

In conclusion, the weight of influence on the SMEs' credit risk of five first grade indexes is in the following order--business owners status（A_5,0.287 920）> enterprises operating environment (A_3, 0.244 814）> credit guarantee way（A_4,0.201 207）>corporate balance sheets (A_1,0.156 613）> enterprise management status （A_2,0.109 446）.

The secondary indexes belonging to A_1(corporate balance sheets) are calculated as the following.

$\overline{h_{B11}} = 0.652478,\ \overline{h_{B12}} = 0.480850,\ \overline{h_{B13}} = 0.302853.$

Table3. *Weights of influence of the secondary indexes*

The 1st index	The 2nd index	The value of weight
enterprise management status (A$_2$)	credit status B$_{22}$	0.652 478
	innovation capability B$_{23}$	0.480 750
	development sustainability B$_{21}$	0.302 853
enterprises operating environment(A$_3$)	market share B$_{33}$	0.454 346
	economic policyB$_{31}$	0.334 765
	prospect of the industry B$_{32}$	0.210 889
credit guarantee way(A$_4$)	pledge B$_{42}$	0.454 346
	mortgage B$_{41}$	0.334 765
	third-party guarantee B$_{43}$	0.210 889
business owners status（ A$_5$）	personal credit status B$_{52}$	0.454 346
	personal finances B$_{51}$	0.334 765）
	level of enterprise managementB$_{53}$	0.210 889

The weights of influence of the three secondary indexes are in the order of B$_{11}$（solvency, 0.454 346）> B$_{12}$（profitability, 0.334 765）>B$_{13}$（development ability, 0.210 889）.

The other weights of influence of the three secondary indexes are shown in Table 3.

4.3. Calculating Weight of the Indexes

Multiplication method will be applied to calculate combination weight of the indexes (W$_{Bij}$). The results are shown in Table 4.

Table4. *Contribution degree influencing SMEs' credit risk*

indicator layer A$_i$（weight W$_{Ai}$）	indicator layer B$_{ij}$	Weight （W$_{Bij}$）
A$_1$（0.156 613）	B$_{11}$	0.071 156
	B$_{12}$	0.052 429
	B$_{13}$	0.033 028
A$_2$（0.109 446）	B$_{21}$	0.023 081
	B$_{22}$	0.071 081
	B$_{23}$	0.052 373
A$_3$（0.244 814）	B$_{31}$	0.081 955
	B$_{32}$	0.051 629
	B$_{33}$	0.111 230
A$_4$（0.201 207）	B$_{41}$	0.067 357
	B$_{42}$	0.091 418
	B$_{43}$	0.042 433
A$_5$（0.287 920）	B$_{51}$	0.096 386
	B$_{52}$	0.130 815
	B$_{53}$	0.060 719

It can be seen from table 4 that among the 15 influencing factors, enterprise financial indicator, which is the most important factors in the large and medium-sized enterprises credit risk evaluation, makes no difference for the SMEs. The weight is fixed as low as 0.156613. In contrast, individual case of owners is ranked firstly with the weight of 0.287920. This phenomenon is closely connected with the characteristics of small and medium-sized enterprises. The majority of SMEs is developed by personal endeavor. Reasonable corporate governance structure has not been built. Additionally, the mechanism of internal balance is not sound. SMEs' ability and willingness of repayment are largely dependent on the business owners. At last, accounting information distortion leads to reflecting the real production situation inaccurately.

5. CONCLUSION

According to the fuzzy analytic hierarchy process (FAHP), influence degrees which will bring risks upon the commercial banks can be calculated combining the qualitative parameters and the quantitative ones. The weights contribute to formulating scoring system of SMEs' credit risk. In view of the result, commercial banks should pay more attention to subjective evaluation of business owners and the enterprise operation environment. It is required for commercial banks to effectively identify the credit risk. That's the only way that bank assets can be ensured and the total benefit be improved.

REFERENCES

Jijun Z. (2000). Fuzzy Analytic Hierarchy Process (FAHP). Fuzzy Systems and Mathematics, 02, 80 - 88.

Yudan D &Yongbo Y. (2011). The research on risk forewarning of credit for commercial banks ---based on AHP model of variable fuzzy weight. Techno-economics & Management Research, (12), 82-87.

Deloitte financial services center in China. (2013). Annual report analysis of China's listed bank in 2012.

Xiaohong C. (2000).Financing of SMEs .Economic Science Press, 55-61.

Sujuan W & Junpeng W. (2013). Analysis on influence degree of SMEs' credit risk—based on FAHP. Science and Industry, 4 , 76-79.

William D. Bradfand. (2008). Cresting government financing programs for small and medium sized enterprises in China theory and practice. China and world economy, 45, 112-126.

Vojistac Maksimovie. (2009). Research and development China's macroeconomic impact of the financial global economy. Journal of Finance, 2, 34.

Wolf Wagner. (2010). Loan market competition and risk-taking.Journal of Financial Services Research, `22, 71-81.

VaIentina Hartarska & Denis Nadolnyak. (2012). A Framework for Regulating MicrofinanceInstitutions. Financial Sector Development Department, 12, 134-239.

Rubana Mahjabeen. (2008). Principles and Practices for Regulating and Supervising Microfinance. Inter-American Development Bank, 219-253.

The World Bank Development Research Group Finance and Private Sector Team. (2009). Does Regulatory Supervision Curtail Microfinance Profitability and Outreach. Policy Research Working Paper ,06, 19-23.

]Ghosh D.Ray. (2012). Microfinance Regulation and Supervision Concept Paper. Journal of Finance,11, 323-368.