

Construction and Application of the Technology-based SMEs Credit Risk Assessment Index System*

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Abstract—It is necessary to build up the scientific and effective index system of credit risk assessment of the Technology-based SMEs. Based on the previous research of credit risk assessment system of the technology-based SMEs by home and abroad scholars, this paper is to find out the existed problems of credit risk assessment system of the technology-based SMEs, and according to the designation principle of the credit risk assessment index system, try to construct a more concise, more practical and more targeted credit risk assessment index system. Finally, the constructed credit risk assessment index system of the technology-based SMEs is verified by the fuzzy comprehensive assessment (FCE) method.

Keywords—*technology-based SMEs; credit risk; credit risk assessment; index system; FCE*

I. INTRODUCTION

Technology-based SMEs are a kind of market-oriented knowledge-intensive economic entity with independent operation module. R&D members as core strength, technology-based SMEs are mostly engaged in the science research, designation, production and sale of high technology products. Innovation is the mission and existence means of technology-based SMEs, it is very helpful for technology-based SMEs to transform input into output, and simultaneously provide more employment opportunities during the transformation process. Technology-based SMEs can focus on the market which is ignored by most of large enterprises, thus form a useful replenishment and result in the optimizer economic structure. Technology-based SMEs have a great impact on the national economic development.

However, most of the commercial banks are reluctant to provide financing to technology-based SMEs, the most important reason is that financing stage of technology-based SMEs lies in the front of technology-based SMEs commercial success stage, then in that time, commercial banks is hard to evaluate the monetary value of the most valuable patent, trademark and some other technological products. And it is more difficult to identify the facing technology risk and operation risk of technology-based SMEs. This result in the formation of so-called economics

*Fund Project: Guizhou Science and Technology Department Youth Science and Technology Talent Growth Project (contract of Guizhou Provincial Education Department KY[2017]228); Guizhou Provincial Education Department Education Planning Key Project (2017A009); Guiyang Baiyun District Science and Technology Project (Contract of Science and Technology Bureau of Baiyun District [2017] No. 40).

‘information asymmetry’ dilemma between commercial banks and technology-based SMEs, thus cause commercial banks ‘credit reluctance’ to technology-based SMEs. In order to solve this problem, building a ‘bridge’ between commercial banks and technology-based SMEs is necessary, the bridge is to construct a credit risk index system and make commercial banks can evaluate scientifically and accurately the credit risk of technology-based SMEs. According to the development features of technology-based SMEs and combining with real national conditions, the paper is target to construct technology-based SMEs credit risk assessment index system and strive to reflect scientifically and accurately the credit status of technology-based SMEs.

II. CONSTRUCTION OF TECHNOLOGY-BASED SMEs CREDIT RISK ASSESSMENT INDEX SYSTEM

A. Construction Principle of Technology-based SMEs Credit Risk Assessment Index System

A scientific and comprehensive technology-based SMEs credit assessment index system can ensure commercial banks to get objective and fair credit assessment result of technology-based SMEs. The construction principles of technology-based SMEs credit risk assessment index system as following:

1) *Comprehensiveness*: The designed content of credit assessment index system should reflect comprehensively all of elements influencing technology-based SMEs credit status. Not only consider the past achievements of technology-based SMEs, but also predict the future development status of technology-based SMEs. Not only consider its self-situation, but also take social environment induced effect into account. Only in this way, Comprehensive credit risk inspection of technology-based SMEs can be obtained. If the obtained conclusion is based on small number of indexes, this can lead to a failure assessment result.

2) *Strong operability*: The designed credit assessment index system need have high practical applicability, and it should be easy to operate and design computer running program. Too much assessment grade and index numbers can complicate the whole assessment process and add the practical operation difficulty. Too few assessment grade and index numbers can result in the random operability of

assessment agency or corresponding staff and make the assessment result lose fairness and impartiality. Therefore, it is necessary for the designation of index system to consider comprehensively and construct reasonably assessment grade number and index number, and ensure assessment index system with high practical operability.

3) *Scientific*: For the constructed technology-based SMEs credit assessment index system, it is necessary to integrate organically various designed indexes, and avoid the contradiction and overlap between various indexes. In addition, the calculation of index and assessment method must be scientific and have strong basis. Especially in the assessment index designation of financial condition, overcoming the shortage of traditional finance assessment index system is necessary.

4) *Strong pertinence*: For the constructed technology-based SMEs credit assessment index system, it should aim at unique characteristics of technology-based SMEs so as to screen some indexes. Constructing the credit assessment index system of technology-based SMEs should focus on four aspects: future, innovation, development and growth of technology-based SMEs. These characteristics have decided that technology-based SMEs credit assessment index system should pay more attention to the reflection of future, innovation, development and growth of enterprise.

5) *Legality*: Credit assessment must comply with corresponding national policy, law and regulation. This system should embody the guidance function of national macroscopic policy aiming to technology-based SMEs. For the economic benefits index and risk supervision index with standard value which are established by corresponding national government agencies, this requirement must be embodied in the constructed index system.

B. Technology-based SMEs Credit Risk Assessment Index System

In accordance with the construction principle of technology-based SMEs credit assessment index system, and referring to the employed index system by our country commercial banks and credit rating agencies and home and abroad corresponding literatures [1]~[16], and combining with the unique characteristic of technology-based SMEs, the paper has constructed technology-based SMEs credit risk assessment index system with two grades index. The first grade index includes mostly eight aspects of indexes: the debt paying capability, profitability, operation capability, development capability, innovation capability, enterprise quality, enterprise credit record, and enterprise development prospect. Under the second grade index, twenty aspects of indexes are designed. The designed technology-based SMEs credit assessment index system is shown in "Table I". The detailed connotation of the first grade index as follows:

1) *Debt paying capability*: The debt paying index includes mostly two indexes: Current ratio and asset-liability ratio. Debt paying capability is the ability of using its asset to pay the long and short term debt. Choosing

current ratio and asset liability ratio is due to these two indexes can make more comprehensive assessment to the asset liquidity of enterprise. Under debt paying capability index, a lot of home and abroad scholars used to adopt more indexes to make assessment. In fact, there is high relativity between many indexes, like current ratio and quick ratio, selecting simultaneously these two indexes is no necessary, just one is feasible.

2) *Profitability*: Profitability is defined as the ability of enterprise getting profit. It includes mostly the following three indexes: the gross margin of main income, the return ratio of net assets and earnings retention ratio. However, the profit is the fund resources from where investor to get investing return and creditor to get principal and interest. So, the profit is very important for investor and creditor, and it is a key factor of influencing enterprise credit.

3) *Operating capability*: The operating capability includes mostly the following three indexes: inventory turnover rate, accounts receivable turnover ratio and the ratio of current assets to total assets. The operating capability of technology-based SMEs can influence directly the enterprise profitability. The higher operating capability can achieve the higher profitability, and the lower operating capability will result in the lower profitability. The whole finance analysis is consisted of operating capability, profitability and debt paying capability, and it is must be taken most basic analysis of assessing enterprise credit risk status.

4) *Enterprise growth capability*: The enterprise growth ability is the basis of enterprise future long-term existence and development, and it embodies the enterprise development potential. The growth capability mostly includes the following three indexes: the net profit growth rate, total assets growth rate and the main business growth rate. For the technology-based SMEs that want to win the drastic business competition, forming continuous development potential is very important. The technology-based SMEs with bigger development potential will no doubt get better credit risk assessment result, and it is easier to obtain fund.

5) *Technology innovation capability*: The enterprise technology innovation capability mostly includes three indexes: new product sale income rate, R&D member rate and R&D inputting intensity. The new product sale income rate index reflects the enterprise innovation transformation ability. R&D member rate and R&D inputting intensity can reflect the inputting intensity of enterprise innovation. For the technology-based SMEs, the innovation transformation ability and innovation inputting intensity are the existent basis of enterprise. So, in the course of making the credit risk assessment of technology-based SMEs, the enterprise technology innovation capability is a very important index.

6) *Quality of enterprise*: The quality of enterprise includes two indexes that they are administrator's quality, culture and strategy of enterprise. For the SMEs, the

existence and development of enterprise rely directly on the administrator's quality, and especially in the technology-based SMEs. In modern company, the enterprise culture and strategy have been becoming more and more important. It not only is an important soft factor of keeping enterprise sustainable development, but also is the reflection of enterprise business philosophy and values.

7) *Enterprise credit record*: The enterprise credit record contains two indexes: fulfilling commercial contract record

and repaying loan history record. Fulfilling commercial contract record reflects directly the operating efficiency of enterprise, and repaying loan history record embodies directly the financing credit status of enterprise. Enterprise credit record is one of important factors reflecting enterprise credit. It can give the feedback of the past credit status of enterprise, and embody the current honesty level of enterprise and predict the future honesty level of enterprise in "Table I".

TABLE I. CREDIT RISK ASSESSMENT INDEX SYSTEM OF TECHNOLOGY-BASED SMEs

Target layer	Index layer			
	First grade index	Code of first grade index	Second grade index	Code of second level index
Credit risk assessment index system of technology-based SMEs	Debt paying capability	X ₁	Current rate	X ₁₁
			Asset-liability rate	X ₁₂
	Profitability	X ₂	Net margin ratio of main business	X ₂₁
			Revenue ratio of net asset	X ₂₂
			Revenue retention rate	X ₂₃
	Operating capability	X ₃	Inventory turnover rate	X ₃₁
			Accounts receivable turnover rate	X ₃₂
			Ratio of current assets to total assets	X ₃₃
	Growth capability	X ₄	Net profit growth rate	X ₄₁
			Total assets growth rate	X ₄₂
			Main business growth rate	X ₄₃
	Technology innovation capability	X ₅	New product sale income rate	X ₅₁
			R&D member rate	X ₅₂
			R&D inputting intensity	X ₅₃
	Enterprise quality	X ₆	Administrator's quality	X ₆₁
			Enterprise culture and strategy	X ₆₂
Enterprise credit record	X ₇	Fulfilling commercial contract record	X ₇₁	
		Repaying loan history record	X ₇₂	
Enterprise development prospect	X ₈	Industry prospect	X ₈₁	
		Technology life cycle	X ₈₂	

8) *Enterprise development prospect*: The enterprise development prospect contains two indexes: industry prospect and technology life cycle. These two indexes can well reflect the dynamic change of enterprise. The significant feature of technology-based SMEs is big development potential. In order to embody this characteristic in credit risk index system, it must depend on the assessment of technology-based SMEs industry prospect and enterprise technology life cycle.

III. EMPIRICAL ANALYSIS

A. Sample Selection and Data Description

Generally, it is difficult to obtain the financial data and administration information of non-listed technology-based SMEs. Then, getting the financial data and administration information of listed technology-based SMEs is relatively easy. Hence the paper selects the Shuang Lu pharmacy listed in Shenzhen SMEs board as the research sample, and applies fuzzy comprehensive assessment method to make empirical analysis on the designed index system in above. Shuang Lu pharmacy has been named in the list of high and new technology enterprises of national torch plan and the list of first batch "100 innovation enterprises" of Zhong Guan country, thus, selecting Shuang Lu pharmacy as the sample of technology-based SMEs is feasible. The adopted data is

the latest published data which come from He Xun net (<http://www.hexun.com>) and the homepage of Shuang Lu pharmacy company website (<http://www.slpharm.com.cn/web/main/index.jsp>) (September 30, 2018).

B. Fuzzy Comprehensive Assessment

In this paper, the fuzzy comprehensive assessment method is employed to make the credit risk assessment of Shuang Lu pharmacy (002038)[7]. First, determining the factor box: $U = (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) = \{(X_{11}, X_{12}), (X_{21}, X_{22}, X_{23}), (X_{31}, X_{32}, X_{33}), (X_{41}, X_{42}, X_{43}), (X_{51}, X_{52}, X_{53}), (X_{61}, X_{62}), (X_{71}, X_{72}), (X_{81}, X_{82})$, then, excellent, good, fair, poor and worse this five grades are adopted to indicate the enterprise credit rating, and the comment box is $V =$ (excellent, good, fair, poor and worse)

1) *Determination of index weight*: AHP method is employed to determine the index weight. The following "Table II" shows the obtained weight result.

TABLE II. INDEX WEIGHT

Target layer	Index layer			
	Code of first grade index	Weight of first grade index	Code of second grade index	Weight of second grade index
Credit risk assessment index system of technology-based SMEs	X ₁	0.085	X ₁₁	0.333
			X ₁₂	0.667
	X ₂	0.085	X ₂₁	0.252
			X ₂₂	0.589
			X ₂₃	0.159
	X ₃	0.085	X ₃₁	0.250
			X ₃₂	0.250
			X ₃₃	0.500
	X ₄	0.133	X ₄₁	0.334
			X ₄₂	0.333
			X ₄₃	0.333
	X ₅	0.227	X ₅₁	0.297
			X ₅₂	0.164
			X ₅₃	0.539
	X ₆	0.075	X ₆₁	0.667
			X ₆₂	0.333
X ₇	0.236	X ₇₁	0.333	
		X ₇₂	0.667	
X ₈	0.074	X ₈₁	0.333	
		X ₈₂	0.667	

2) *Determination of membership degree*: The fuzzy comprehensive assessment method is employed to determine the membership degree of index. The designed credit risk assessment index system of technology-based SMEs includes quantitative index and qualitative index. The determination of quantitative index is a complex process. First, taking the <Enterprise performance assessment standard value> which established by SASAC of the State Council as limits, then inserting three grading standard point with the same distance between limits. Based on that, the

quantitative index grade membership function is obtained, thus the membership degree matrix can be calculated. The determination of qualitative index membership degree is based on the Delphi method. Corresponding expert is invited to grade for each qualitative index according to the comments box and calculating out the frequency of each assessment index belonging to its grade, subsequently, the membership degree matrix is obtained. The following "Table III" shows the calculated membership degree.

TABLE III. MEMBERSHIP DEGREE

Target layer	Assessment index		Index quality	Reference standard		Enterprise related data	Membership degree	
	First grade index	Second grade index		Excel-lent	Poor			
Credit risk assessment index system of technology-based SMEs	Debt paying capability	Current rate	Quantitative index	≥ 25.9	≤ -1.2	21.24	(0,0.97,0.03,0,0)	
		Asset-liability rate		≤ 37.5	≥ 71.8	0.04	(1,0,0,0,0)	
	Profitability	Net margin ratio of main business		≥ 41.6	≤ 13.4	0.7	(0,0,0,0,1)	
		Revenue ratio of net asset		≥ 17.9	≤ -0.7	0.18	(0,0,0,0.28,0.72)	
		Revenue retention rate		≥ 6.4	≤ -0.8	4.4	(0,0.67,0.33,0,0)	
	Operating capability	Inventory turnover rate		≥ 9	≤ 3.3	2.67	(0,0,0,0,1)	
		Accounts receivable turnover rate		≥ 4	≤ 2	2.84	(0,0,0.69,0.31,0)	
		Ratio of current assets to total assets		≥ 0.7	≤ 0.1	0.66	(0.3,0.7,0,0,0)	
	Growth capability	Net profit growth rate		≥ 24.9	≤ -6.3	-0.21	(0,0,0.09,0.91,0)	
		Total assets growth rate		≥ 18.4	≤ -2.9	0.22	(0,0,0.88,0.12)	
		Main business growth rate		≥ 21.8	≤ 3.3	0.46	(0,0,0,0,1)	
	Technology innovation capability	New product sale income rate		≥ 20	≤ 10	27	(1,0,0,0,0)	
		R&D member rate		≥ 30	≤ 10	90	(1,0,0,0,0)	
		R&D inputting intensity		≥ 8.75	≤ 3	15.5	(1,0,0,0,0)	
	Enterprise quality	Administrator's quality		Qualitative index	N/A	N/A	N/A	(0.2,0.5,0.2,0.1,0)
		Enterprise culture and strategy			N/A	N/A	N/A	(0.3,0.5,0.2,0,0)
Enterprise credit record	Fulfilling commercial contract record	N/A	N/A		N/A	(0.3,0.4,0.3,0,0)		
	Repaying loan history record	N/A	N/A		N/A	(0.3,0.6,0.1,0,0)		
Enterprise development prospect	Industry prospect	N/A	N/A		N/A	(0.2,0.6,0.2,0,0)		
	Technology life cycle	N/A	N/A		N/A	(0.3,0.3,0.4,0,0)		

^a. Attention: Quantitative index standard refer to the <Enterprise performance assessment standard value> established by SASAC of the State Council.

3) *Enterprise credit score*: According to the above data, it is easy to calculate out the fuzzy matrix composed by assessment vector of each first grade index factor.

$$R = \begin{bmatrix} 0.67 & 0.32 & 0.01 & 0 & 0 \\ 0 & 0.11 & 0.05 & 0.16 & 0.68 \\ 0.15 & 0.35 & 0.17 & 0.08 & 0.25 \\ 0 & 0 & 0.03 & 0.60 & 0.37 \\ 1 & 0 & 0 & 0 & 0 \\ 0.233 & 0.5 & 0.2 & 0.067 & 0 \\ 0.3 & 0.533 & 0.167 & 0 & 0 \\ 0.267 & 0.4 & 0.333 & 0 & 0 \end{bmatrix}$$

Then, based on the first grade index weight in "Table III", the fuzzy comprehensive assessment result of enterprise credit risk rank can be calculated:

$$B=(0.4047, 0.2592, 0.1026, 0.1052, 0.1283)$$

In accordance with the biggest membership degree principle, the credit risk assessment rank of Shuang Lu pharmacy (002038) is excellent.

IV. CONCLUSION

On the basis of research about technology-based SMEs credit assessment index system that done by home and abroad scholars, and in accordance with the construction principle of credit risk assessment index system, the paper has constructed distinctive credit risk assessment index system aiming at our country technology-based SMEs and try to further improve this credit risk assessment index system. Finally, this index system is verified by applying fuzzy comprehensive assessment method to analyze the selected sample. For the technology-based SMEs, this type of the credit risk assessment index system can be considered as self-diagnosed tool, and through improving each related index score in this index system can enhance its financing capability. For commercial banks, this type of the constructed credit risk assessment index system of technology-based SMEs is helpful to solve the problem of 'information asymmetry' in the course of making credit risk assessment for technology-based SMEs and improve the working efficiency of commercial banks. The innovation point of this paper is that the index reflecting enterprise dynamic change is introduced to the process of constructing technology-based SMEs credit risk assessment index system, it can reminds commercial bank should pay close attention to enterprise dynamic change during making enterprise credit risk assessment. In the empirical part of this paper, the fuzzy comprehensive assessment method is employed. Because the determination of index weight is depend heavily on the AHP method with strong subjectivity, thus result in the final obtained enterprise credit score with obvious subjectivity. So recently, writer will work on seeking a more objective credit risk assessment method to collocate the constructed technology-based SMEs credit risk assessment index system.

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