Research on the Model of Household Credit Risk Evaluation of Rural Microfinance

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Abstract Since rural microfinance is a credit which grants loans without collateral and guarantees to farmers, it is considerably important to evaluate and control the household credit risk. Through establishing the evaluation index system and then using catastrophe progression theory, three common types of catastrophe system and the normalization formula, we get the comprehensive evaluation. Finally, we take the empirical test and the result shows that this method is simpler and more objective which can be used by the credit cooperatives to decide whether to authorize the loans.

Key words Rural Microfinance, Credit Risk, Catastrophe Theory, Comprehensive Evaluation, China

1 Introduction

Rural microfinance is a credit which grants loans without collateral and guarantees to farmers based on their credibility within the ratified loan limit and period of time. Since rural microfinance was introduced to China. It has been playing an important role in promoting peasants' incomes, and at the same time its width and depth have been further broadened. Nevertheless, in the practice and implementation, a series of problems concerning household credit risk have also been exposed. Especially, the issue of how to control the household credit risk effectively has captured lots of attention from scholars at home and abroad. Thus, establishing an objectively scientific and highly applicable household credit risk evaluation system has gradually become a major part of the rural financial supervision.

There are many methods which have been proposed to evaluate the credit risk, although some of them are to some extent subjective and others are too complicated to put into practice. Major methods[1] to evaluate credit risk include the Regression model method, the system analysis method, the BPANN (BP Artificial Neural Network) method, and some other methods based on gray system theory or attribute recognition theory.

The application of the Regression model method is based on a large number of actual survey data, but it is still difficult to accurately express the complex relationships between the subjective aspects and objective ones in the process of evaluation. Moreover, this method, to a large extent, is subject to geographical restrictions. The system analysis method, represented by AHP (Analytical Hierarchy Process) and fuzzy mathematical analysis, is clear and theoretically strong. However, both of these two typical methods use the scores given to farmers by experts which are too subjective. Consequently, it is difficult to obtain the objective and fair evaluation of household credit risk. It is difficult to build the model using the BPANN (Back Propagation Artificial Neural Network) method, because BP itself is prone to get a local best answer and has the shortcoming of slow convergence. There are also some other household credit risk evaluation methods, such as those based on gray system theory or attribute recognition theory. But, the calculation of the latter method is very complicated. Although the former one can better solve the issue that the evaluation index is fuzzy and complex, the determination of weight functions, thresholds of indexes and cluster coefficients needs to rely on the experience-based scope of each index. Moreover, this method is, to some extent, subjective. And because the final result is the synthesis of cluster analysis of all the indexes, it is hard to decide whether to accept the result or not when each cluster differs little.

In addition, if the selection of evaluation indexes is scientific, it will be more conducive to ensuring the accuracy of the results. The weighted mean is commonly used in the calculation of all these methods, which means the weightings of the indexes remain constant no matter how their values change. Whereas, on the whole, when one of the indexes is particularly prone to cause more risks, no matter what method we use, it is possible that this index is neutralized by others. And thus, in reality, it is unable to highlight the increase in credit risk, which then leads to the diminishment of objectivity and fairness in evaluation.

Of course, we can also use variable weightings in evaluation, which means the weightings of indexes can have different values under different conditions. But, the evaluation process will be more complex and at the same time, the application of the method is also subject to certain limitations.

This paper attempts to decrease the defects of the previous methods to the maximum extent, and thus we put forward a new method based on catastrophe theory. In the process of evaluation, there is no need to determine the weightings of the indexes artificially, and all that we need to do is ranking the in-

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dexes according to their importance. And the empirical study is also conducted by taking the typical 15 households in Yangling County, Shaanxi Province as evaluation objects. They are typical because they are mutually different and represent most of other farmers' credit characteristics. The research shows that this model is simple, operable and the results are more in line with the actual situation, which can be used as a basis for credit cooperatives to make lending decisions.

2 Methodology and Data

The main methodology applied in this study is Catastrophe Theory[2] proposed by French mathematician Rene Thom in his book *Structural Stability and Morphogenesis*. In 1972. Rene Thom demonstrated that this theory could be used to solve the issues caused by discontinuous changes in social phenomena. Catastrophe phenomena are widespread in our real life, such as the economic collapses, the sudden closure of an enterprise, a sudden change in the credit rating, *etc*. There are 7 basic models in Rene Thom's elementary catastrophe theory, which are called as the fold catastrophe model, the cusp catastrophe model, the swallowtail catastrophe model, the butterfly catastrophe model, the hyperbolic umbilical catastrophe model, the elliptic umbilical catastrophe model, and the parabolic umbilical catastrophe model.

Each catastrophe model is determined by a potential energy function $f(x)$, and the complete picture of the catastrophe process can be described by the corresponding profile of equilibrium which can be obtained by setting the first derivative of the potential function equal to 0, ($f'(x)=0$). The profile of equilibrium expresses a certain state after the combined effects of a state variable and several control variables. Another concept is Singularity set which can be obtained by setting the second derivative of the potential function equal to 0, ($f''(x)=0$). It expresses the set of catastrophe state in the profile of equilibrium. In order to get the bifurcation set which is expressed by the state variable and used to describe the relationship between the state variable and the control variables, we form an equation set by setting every derivative equal to 0. The bifurcation set means that when the control variables are in the bifurcation set it will generate catastrophe of the system state.

In order to simplify the actual calculation, the range of the state variable and the control variables must be from 0 to 1. The values of the variables which are between 0 and 1 are called catastrophe membership function or catastrophe progression. Thus we use the normalized formula which is obtained through transforming the equations of bifurcation set to solve this problem. The normalized formula makes the ranges of all different variables into the same one which is from 0 to 1. Thus through normalization we have translated the different qualitative conditions of different control variables in the system into the same one which is expressed by the state variable.

The specific steps of the methodology are as follows:

First, setting up the evaluation index system.

According to the purpose of the evaluation, the paper divides the general index[3]—household credit risk in rural microfinance—into several contradictory sub-indexes. We then repeat this step for all the sub-indexes after arranging them into a hierarchical structure so as to quantitatively evaluate the credit risk. Because the number of the control variables in the basic catastrophe system does not exceed 4, we should also keep the number of sub-indexes under the same index under 4.

Second, choosing the types of the catastrophe system.

Supposing that x is the state variable, and a, b, c, d are control variables. This paper uses the three common types of catastrophe system, which are the cusp catastrophe system, the swallowtail catastrophe system and the butterfly catastrophe system.

Third, using the normalized formulas to evaluate comprehensively.

In the evaluation based on catastrophe theory, if there is no significant interrelationship between indexes of the same system, we should adopt the minimax principle when calculating the value of x by the normalized formula. Otherwise, we should comply with the principle of complementarity, using the average instead. Finally, when sorting the evaluation objects, we should adopt the maximin principle according to the score of the general index[4].

3 Empirical research

3.1 Selecting the sample This paper takes the data concerning typical 15 households supplied by RCC in Yangling as the evaluation object.

(1) Building the index system of household credit risk evaluation.

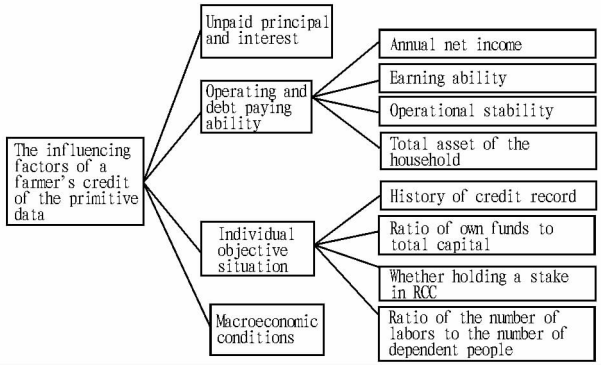

Fig.1 The index system of household credit risk evaluation

Firstly, we divide the factors which may influence household credit risk into 3 secondary indexes. Here, the index system consists of three aspects: debt paying ability, operational ability and the objective situation of farmers. And this is a swallowtail catastrophe system. In addition, the Index of debt paying ability is divided into the value of total assets, net income every year, the situation of credit record, which is also a swallowtail catastrophe system; farmers' operating ability is divided into earning ability and operating stability, which is a cusp catastrophe system; and the objective situation of farmers includes the ratio of the number of labors to the number of de-

pendent people, the ratio of own funds to total capital needed, the performance of law-abiding, morality and neighborhood relations, and the situation of whether holding a stake in RCC, which is a butterfly catastrophe system.

(2) Normalization of the primitive data.

Before the comprehensive evaluation, we need to standardize the raw data, converting them into catastrophe progression, which are between 0 and 1. For the index the bigger the better, we chose the model $\sigma = x/x_{max}$. And for the index the smaller the better, we select the model $\sigma = x_{min}/x$, in which x_{max} is the maximum value of the same column, x_{min} is the minimum value of the same column, x is the actual value.

Table 1 The Primitive Data

Farmer	①(￥)	②(10^4￥)	③	④	⑤(10^4￥)	⑥	⑦	⑧	⑨
Farmer 1	51 125.38	10	A	Contracting projects	20	A	>50%	Y	1/2
Farmer 2	20 492.23	5	A	Owning a grocery, regular wages	20	A	>50%	Y	2/4
Farmer 3	51 294.41	10	A	Leasing building materials	120	B	>30%	Y	2/3
Farmer 4	51 927.45	5	A	Doing construction business	50	A	>50%	Y	2/4
Farmer 5	20 478.06	3.5	B	Driving a taxi	10	A	>50%	N	2/4
Farmer 6	21 162.30	2	C	Working as migrant workers	10	B	>30%	N	2/5
Farmer 7	10 369.10	4	B	Transporting	16	B	>50%	N	2/5
Farmer 8	20 926.97	3	C	Working as migrant workers	3	B	<30%	N	2/5
Farmer 9	21 638.44	4.5	B	Migrant-working, commission agent	10	C	>50%	N	3/4
Farmer 10	8 637.54	3.5	B	Feeding cattle	10	B	>50%	N	2/4
Farmer 11	8 311.95	1.5	C	Farming	8	C	>30%	N	2/3
Farmer 12	7 471.48	1	D	Working as migrant workers	10	B	>30%	N	3/5
Farmer 13	4 119.64	2	C	Farming	4	B	>30%	N	3/4
Farmer 14	10 299.10	1.5	D	Doing odd jobs	5	C	<30%	N	2/3

Note: A means very good, B means all right, C means just average and D means bad. Y means the household holds a stake in the credit cooperative. N is just the opposite. The contents represented by the encodings are: ① the unpaid principal and interest (based on the real monthly interest rate ; ②means the net annual income; ③means the earning ability; ④means the operational stability; ⑤means the total asset of the household; ⑥means the credit historical record; ⑦means the ratio of own funds to total capital needed; ⑧means the situation of whether holding a stake in RCC; ⑨means the ratio of the number of labors to the number of dependent people.

Table 2 The Evaluation Sheet of Household Credit Risk in RCC of Yangling, Shaanxi Province

	A	B	C	D
The situation of credit records	25	15	5	0
Earning ability	30	15	10	5
Operating stability	20	15	10	5
The ratio of own funds to total capital needed	5	3	0	0
The situation of whether holding a stake in RCC	Y5	N0		

Note: Operating stability can be reflected by the farmer's job, and according to the RCC's rules "getting regular wages, leasing, running a hotel and owning a grocery" gets A; "Supplying delivery service, contracting projects , doing building business, driving a taxi" gets B; "being a commission agent, transporting , feeding cattle, working as migrant workers" gets C; "doing odd jobs" gets D; and; A farmer who Abides to the law strictly can get 10 points, otherwise he will get 0; The ratio of own funds to total capital needed is higher than 50% is recorded 5 points, "30% –50%" is recorded 3 points, "below 30%" recorded 0.

Table 3 The Standardized Data

Farmer	①(￥)	②(10^4￥)	③	④	⑤(10^4￥)	⑥	⑦	⑧	⑨
Farmer 1	0.080 1	1.000 0	1.0	0.666 7	0.137 9	1.0	1.0	1	0.166 7
Farmer 2	0.199 9	0.444 4	1.0	1.000 0	0.137 9	1.0	1.0	1	0.166 7
Farmer 3	0.079 8	1.000 0	1.0	1.000 0	1.000 0	0.5	0.6	1	0.450 0
Farmer 4	0.078 9	0.444 4	1.0	0.666 7	0.396 6	1.0	1.0	1	0.166 7
Farmer 5	0.200 0	0.277 8	0.4	0.666 7	0.051 7	1.0	1.0	0	0.166 7
Farmer 6	0.193 5	0.111 1	0.2	0.333 3	0.0517	0.5	0.6	0	0
Farmer 7	0.395 0	0.333 3	0.4	0.666 7	0.103 4	0.5	1.0	0	0
Farmer 8	0.500 3	0.222 2	0.4	1.000 0	0.206 9	1.0	0	1	0.450 0
Farmer 9	0.575 2	0.444 4	1.0	0.666 7	0.008 6	0.5	0	0	1
Farmer 10	0.474 2	0.277 8	0.4	0.333 3	0.051 7	0.5	1.0	0	0.166 7
Farmer 11	0.492 7	0.055 6	0.2	0.333 3	0.034 5	0	0.6	0	0.450 0
Farmer 12	0.548 2	0	0	0.333 3	0.051 7	0.5	0.6	0	0.333 3
Farmer 13	0.994 2	0.111 1	0.2	0.333 3	0	0.5	0.6	0	0.583 3
Farmer 14	0.397 7	0.055 6	0	0	0.008 6	0	0	0	0.450 0
Farmer 15	0.387 0	0.166 7	0.2	0.333 3	0.051 7	0	0	0	0

(6) Using the normalized formula and finding the spot which represents the farmer's information on the equilibrium surface of the butterfly catastrophe according to the farmer's credit rating.

As for operating and debt paying ability M_2 and the farmer's individual objective situation M_3, they are all the butterfly catastrophe system. The indexes ② ③ ④ ⑤ represent a_2, b_2, c_2, d_2 respectively, and then we can get the result as below:

$$x_{a2} = \sqrt{a_2}\ \ x_{b2} = \sqrt[3]{b_2}\ \ x_{c2} = \sqrt[4]{c_2}\ \ x_{d2} = \sqrt[5]{d_2}$$

$$M_2 = (x_{a2} + x_{b2} + x_{c2} + x_{d2})/4$$

As the same reason that as for the indexes ⑥⑦⑧⑨ represent c_3, d_3, a_3, b_3 respectively, and then we can get $M_3 = (x_{a3} + x_{b3} + x_{c3} + x_{d3})/4$. Finally we get the graph by the software of matlab, and then find out the spot which can represent the information of the farmer's credit rating on it when $b = 0$.

Table 4 The ranking of farmers' credit ratings

Farmer	M_1	M_2	M_3	The final result	Ranking
Farmer 1	0.080 1	0.833 3	0.887 6	0.600 3	6
Farmer 2	0.199 9	0.833 3	0.887 6	0.640 3	4
Farmer 3	0.079 8	1.000 0	0.877 5	0.652 4	3
Farmer 4	0.078 9	0.841 9	0.887 6	0.602 8	5
Farmer 5	0.200 0	0.686 9	0.637 6	0.508 2	10
Farmer 6	0.193 5	0.563 0	0.435 9	0.397 5	13
Farmer 7	0.395 0	0.719 6	0.460 2	0.524 9	9
Farmer 8	0.500 3	0.777 6	0.691 6	0.656 5	2
Farmer 9	0.575 2	0.709 5	0.460 2	0.581 6	7
Farmer 10	0.474 2	0.627 1	0.597 8	0.566 4	8
Farmer 11	0.492 7	0.528 3	0.417 3	0.479 4	11
Farmer 12	0.548 2	0.237 5	0.609 3	0.465 0	12
Farmer 13	0.994 2	0.469 9	0.644 8	0.703 0	1
Farmer 14	0.397 7	0.172 6	0.191 6	0.254 0	15
Farmer 15	0.387 1	0.578 4	0	0.321 8	14

From the table, the ranking of the credit level of these 15 farmers is identical to the result of attribute recognition model. Thus it indicates that the results of catastrophe evaluation are reliable, and this method is more advantageous in calculation and objectivity.

4 Conclusion

Whether the decisions of authorizing loans are right or not, depends largely on the authenticity and effectiveness of the household survey data. The accuracy of the credit risk assessment method also matters a lot. With the continuous development of modern credit system, the effectiveness of the data related to farmers' credit characteristics has been improved. Therefore, the evaluation of the household credit risk becomes more important. Catastrophe evaluation, as a new evaluation method, combines the merits of the fuzzy analysis and AHP method, which can avoid the subjectivity in a multi-objective decision-making process. The method is simple and strongly applicable, and it is advantageous particularly in ranking the farmers' credit levels.

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