A Study on the Dual Objective Balance Degree of Rural Financial Institutions Based on TOPSIS Comprehensive Evaluation Method

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Abstract—While the social goal of rural financial institutions is to serve the "three rural areas" as their mission, rural financial institutions as enterprises still pursue the economic goal of maximizing their own interests. This paper assesses the balance of the dual objectives of rural financial institutions. Firstly, the subjective weights of the influencing factors are studied by using hierarchical analysis, secondly, the objective weights are studied by using entropy analysis, and finally, the comprehensive weights are obtained by integrating the weights. On this basis, this paper uses the modified TOPSIS method with comprehensive weights to comprehensively evaluate the dual-objective balance degree of rural financial institutions in rural revitalization, taking Shanghai Agricultural and Commercial Bank of China and Agricultural Development Bank of China, a commercial rural financial institution, as examples. The results of the study show that the best completion of dual-goal balance in the ten-year data of Shanghai Agricultural and Commercial Bank was in 2015, and the worst was in 2010. However, China Agricultural Develop-ment Bank gradually improved in the past five years, with the best in 2019 and the worst in 2015.

Keywords- Social Objectives; Economic Objectives; Rural Revitalization; Shanghai Agricultural and Commercial Bank; China Agricultural Development Bank

1 INTRODUCTION

The 19th Party Congress kicked off the prelude of rural revitalization, which is the prerequisite and foundation for the great rejuvenation of the Chinese nation, and rural financial institutions play an important role in the rural revitalization strategy [1]. However, with the continuous development of rural financial institutions towards commercialization, the dual objectives of rural financial institutions cannot be compatible and sustainable, i.e., rural financial organizations prefer to provide larger loans to the rich in order to maximize their own interests and to protect the interests of investors, which then leads to an increase in their average loan size [2]. Therefore, how to coordinate the dual objectives of "economic interest and social responsibility" and find the balance point of the dual objectives is an important guarantee for the sustainable development of rural financial organizations, and an important guarantee for

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solving the financing problems of rural households [3]. As the main institution serving the "three rural issues", rural financial institutions have a strong political significance, namely, the implementation of China's socialist modernization strategy of rural revitalization [4]. This paper explains the social and economic objectives of rural financial institutions from a theoretical perspective and discusses the balance of the banks' dual objectives [5]. It starts from multiple latitudes: return on assets, cost-income approach, share of agriculture-related loans, depth as well as breadth of financial services, making the research direction more comprehensive and three-dimensional.

2 RESEARCH METHODOLOGY

2.1Evaluation index system construction

This paper mainly uses AHP to determine the subjective weights of the factors influencing the dual-objective balance degree of rural financial institutions, determines their objective weights by the entropy weight method, then sets the subjective weights and objective weights to determine the comprehensive weights, and finally uses the obtained comprehensive weights to substitute into TOPSIS to study the specific situation of the dual-objective balance degree of rural financial institutions.

2.2Evaluation index weight determination

2.2.1Determination of subjective weights based on AHP:

Operations researcher T.L. Saaty proposed the hierarchical analysis method (AHP) in the early 1970s, which can simplify the analysis process by hierarchizing the complex decision system through the constructed judgment matrix and calculating the relative importance of each factor, and is therefore suitable for problems that are difficult to analyze quantitatively [6]. When applying this method, the following steps should be followed.

a) Firstly, according to the structural model of hierarchical analysis method [7]. Based on the previously determined based on the objectives, secondary indicators, tertiary indicators divided into target layer, criterion layer and structure layer, then the hierarchy is constructed.

b) The identification of influencing factors. In this paper, the return on capital as A_1, the cost-to-income ratio as A_2, the proportion of agriculture-related loans as A_3, the breadth of financial services as A_4, and the depth of financial services as A_5.

c) Build the judgment matrix in hierarchical analysis. After the index system of the hierarchical analysis method is determined, it is necessary to proceed with the weighting system derived from the comparison of two two factors with each other, after which the rating or ranking of the important degree of weighing can be carried out [8]. In this paper, we mainly use the expert scoring method to quantify the priority of importance, mainly by referring to the experts in related fields, to score the influence factors of the dual target and balance degree one by one, and then remove the maximum and minimum values, and select the average of the remaining numbers to use, so that we can achieve the effect of reducing the error [9]. The comparison of the weight of the importance of the two risk indicators is then carried out, and here it is determined on the basis of the numbers 1 to 9, and their reciprocals, quoted by T.L. Saaty as a

scale. When constructing the judgment matrix, the reciprocal inverse scalar method is usually used to measure the impact factors of the target layer and quantify them, that is, the importance of various risk factors within the secondary index is calculated based on the results of the comparison of two two factors, and the formula (1) is as follows, so as to construct the ratio judgment matrix.

$$a_{ij} = \frac{1}{a_{ji}} \tag{1}$$

d) Calculate the weight vector. The maximum character-istic roots of the judgment matrix are first found to determine the weight values, and then the consistency test is performed.

2.2.2Determination of objective weights based on entropy method:

Entropy is a concept originally used in thermodyna-mics to describe the state of a system in which matter moves thermally [10]. In 1948, the scholar McLaughlin Shannon introduc-ed it into information theory and used the concept of entropy to describe the degree of uncertainty of variables. Because of this property of entropy, the entropy weighting method, which can be quantified, is usually regarded as an objective and comprehensive evaluation method, both for panel data and for multiple variables. The following is the process of calculating entropy weights.

a) Construction of evaluation matrix: First construct the data into an initial evaluation matrix of a × b, where a is the total number of study subjects, b is the number of variables, and v_{ij} denotes the original value of the jth indicator of the ith evaluation subject.

$$V = (v_{ij})_{ab} = \begin{bmatrix} v_{11} & v_{12} & \cdots & \cdots & v_{1b} \\ v_{21} & v_{11} & \cdots & \cdots & v_{2b} \\ \vdots & \vdots & \ddots & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ v_{a1} & v_{a1} & \cdots & \cdots & v_{ab} \end{bmatrix} \tag{2}$$

b) Normalization treatment:

For positive indicators, the treatment is:

$$r_{ij} = \frac{v_{ij} - \max\limits_{1 \le j \le b}(V_{ij})}{\max\limits_{1 \le j \le b}(V_{ij}) - \min\limits_{1 \le j \le b}(V_{ij})} \tag{3}$$

For negative indicators, the treatment is:

$$r_{ij} = \frac{v_{ij} - \max\limits_{1 \le j \le b}(V_{ij})}{\max\limits_{1 \le j \le b}(V_{ij}) - \min\limits_{1 \le j \le b}(V_{ij})} \tag{4}$$

The evaluation matrix after normalizing the data is:

$$R = (r_{ij})_{ab} = \begin{bmatrix} r_{11} & r_{12} & \cdots & \cdots & r_{1b} \\ r_{21} & r_{11} & \cdots & \cdots & r_{2b} \\ \vdots & \vdots & \ddots & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r_{a1} & r_{a1} & \cdots & \cdots & r_{ab} \end{bmatrix} \quad (5)$$

c) Calculating feature weights: The feature weights are denoted by f and are calculated as follows:

$$f_{ij} = \frac{r_{ij}}{\sum_{i=1}^{a} r_{ij}} \quad (6)$$

d) Calculating the entropy value: Denote the entropy value by H and calculate the formula as follows:

$$H_j = -\frac{1}{\ln a} \sum_{i=1}^{a} f_{ij} \ln f_{ij} \quad (7)$$

e) Calculating entropy weight: The entropy weight of an indicator is represented by the following formula.

$$\theta_j = \frac{1-H_j}{b-\sum_{j=1}^{b} H_j} \quad (8)$$

2.2.3Determination of comprehensive weights:

In order to evaluate the importance of each index relatively accurately and objectively, the weights can be integrated, that is, the weights of each index calculated by the hierarchical analysis method, which is subjective, and the weights calculated by the entropy method, which is objective, are integrated using the following formula.

$$\varphi_j = \alpha\omega_j + (1-\alpha)\theta_j \quad (9)$$

In the above equation, α is the coefficient and 0≤α≤1. When α=0, the comprehensive weight is the objective weight determined by the entropy weight method, and when α=1, it is the subjective weight determined by AHP. In this paper, α=0.5 is taken in conjunction with the actual situation of the comprehensive evaluation system of dual-objective balance degree of rural finance.

2.3TOPSIS model based on AHP and entropy weight method

The TOPSIS method, also known as the approximate ideal solution ranking method, is widely used in comprehensive evaluation, which can fully exploit the information of the original data, and the results can reflect the gap between each evaluation solution. TOPSIS mainly evaluates the solutions based on the distance from the ideal optimal solution and the worst solution, that is, the solution closest to the ideal optimal solution and the solution farthest from the ideal worst solution is the best, and vice versa is the worst. The calculation process is as follows:

2.3.1Standardization process:

In order to eliminate the influ-ence of having different magnitudes on the program decision, the matrix normalized in the entropy weight method can be normalized first, with the following formula.

$$Z_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{a} r_{ij}^2}} (i, j = 1,2, \dots ,5; a = 5) \tag{10}$$

2.3.2Calculate the weighted normalized decision matrix:

$$X = Z_{ij} \times \varphi_j \tag{11}$$

2.3.3Calculate the optimal and inferior solutions:

$$h_j^+ = \max (r_{ij}) \tag{12}$$

$$h_j^- = \min (r_{ij}) \tag{13}$$

2.3.4Solving for distance:

$$d_i^+ = \sqrt{\sum_{j=1}^{b} (h_{ij} - h_j^+)^2} \tag{14}$$

$$d_i^- = \sqrt{\sum_{j=1}^{b} (h_{ij} - h_j^-)^2} \tag{15}$$

2.3.5Calculating relative proximity:

$$\varepsilon_i = \frac{d_i^-}{d_i^- + d_i^+} \tag{16}$$

3 EMPIRICAL ANALYSIS

3.1AHP-based weighting calculation

In this paper, we mainly use the expert scoring method to quantify the initial priority of importance, mainly by referring to the reference opinions of dozens of experts in related fields, including banks, "three rural areas", rural financial institutions, government and relevant departments, etc., and come up with the judgment on the dual target balance evaluation system of rural financial institutions The matrix is shown in Table 1 below. In addition, it is necessary to identify the influencing factors, including the return on capital as A_1, the cost-to-income ratio as A_2, the proportion of agriculture-related loans as A_3, the breadth of financial services as A_4, and the depth of financial services as A_5.

TABLE 1. JUDGMENT MATRIX OF THE DUAL-OBJECTIVE BALANCE EVALUATION SYSTEM OF RURAL FINANCIAL INSTITUTIONS

Indicators	A_1	A_2	A_3	A_4	A_5	Weights
A_1	1	7	1/2	5	8	0.3835
A_2	1/7	1	1/6	2	2	0.0891
A_3	2	6	1	4	7	0.3978
A_4	1/5	1/2	1/4	1	3	0.0850
A_5	1/8	1/2	1/7	1/3	1	0.0446

In summary, when CR < 0.1, the consistency test is satisfied. The conclusion obtained is that the factors affecting the balance of dual objectives of rural financial institutions in rural revitalization are, in descending order of influence, the propor-tion of agriculture-related loans, asset return rate, cost-income ratio, breadth of financial services, and depth of financial services.

3.2Evaluation of the dual-objective balance of commercial rural financial institutions

3.2.1Data pre-processing:

In this paper, we use data from Shanghai Agricultural and Commercial Bank (SABC) to empirically analyze the evaluation of the balance of dual objectives of rural financial institutions. Since its establish-ment, Shanghai Agricultural and Commercial Bank has developed into the largest financial institution serving the "three rural areas" in Shanghai. Since its establishment, Shanghai Agricultural and Commercial Bank has become the largest financial institution serving the "three rural areas" in Shanghai. It is committed to serving the real economy, residents and small and medium-sized enterprises, and its profitability has been strengthened, so it is relevant to study the balance of the dual objectives of Shanghai Agricultural and Commercial Bank.

Since the data of Shanghai Agricultural and Commercial Bank is missing, it is necessary to process the missing values first, and then there are three indicators to measure the depth of financial services, so it can be quantified and analyzed by PCA, and then calculated by Matlab, as shown in the following steps.

a) Missing value processing:

The data compiled from the Annual Report and Social Responsibility Report of Shanghai Agricultural and Commercial Bank in previous years are not complete, and according to the scatter plot, curve fitting can be performed.

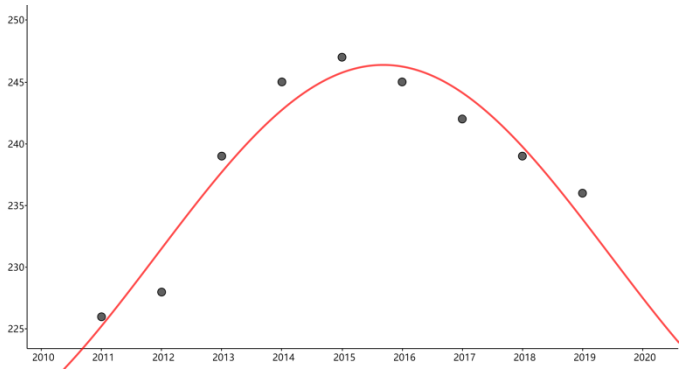

Figure 1. Regression fitting chart of the number of outlets serving the three farmers.

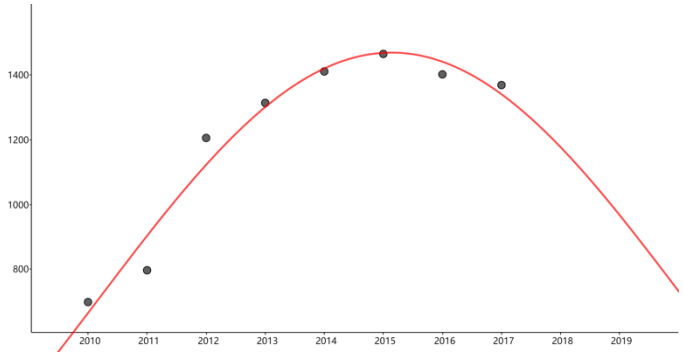

Figure 2. Regression fitting of the number of self-service machines serving the three farmers.

The regression equations obtained with this fitting method are shown below, respectively, then the number of outlets serving the three farmers in 2010 is 220, and the number of self-service machines serving the three farmers in 2018 and 2019 is 1,177 and 967.

$$y_1 = 230.9661 + 15.4096 \times \sin(0.4163x - 1.8009) \quad (17)$$

$$y_2 = 711.6644 + 756.4185 \times \sin(0.3176x + 2.4177) \quad (18)$$

b) Principal component analysis:

Quantitative indicators, the share of agriculture-related loans and the breadth of financial services can be calculated directly using percentages. While more qualitative indicators like depth of financial services need to be screened for each group of data using PCA. PCA is the ability to use a few factors to combine most of the information of all variables.

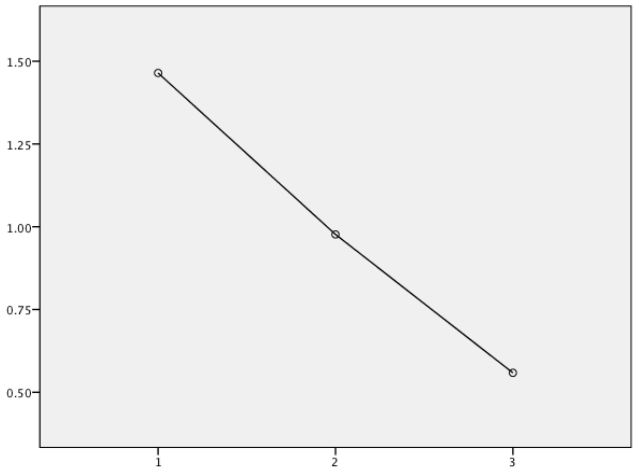

Figure 3. Gravel plot on financial services depth quantification factor.

From the gravel plot, it can be seen that there is only one factor with a characteristic root greater than 1, and for computational simplicity, only one principal component can be extracted in PCA, and the principal component coefficient matrix calculated using SPSS can be further normalized to the final weight of each influencing factor, and the results are shown in the following table.

TABLE 2. PCA CALCULATION RESULTS

Impact Factor	**Customer Satisfaction**	**Self-service machines for the three farmers**	**Public Welfare Donation**
Component Matrix	0.835	0.835	0.264
Variance Percentage	48.81	32.56	18.63
Score coefficient matrix	0.570	0.570	0.181
Normalized weights	0.4315	0.4315	0.1370

3.2.2Results of TOPSIS model based on AHP and entropy weight method:

Among the indicators to measure the dual target balance of rural financial institutions, it is known from the definition that the cost-to-income ratio is used as a negative indicator in the

entropy weight analysis method, while the others are positive indicators [11]. First of all, we get the specific value based on the formula of capital adequacy ratio and agriculture-related loan ratio, while the breadth of financial services is quantified by the number of outlets serving the three rural areas in this paper, and the more the number of outlets serving the three rural areas indicates the breadth of financial services of rural financial institutions.

From Table 2, we get: depth of financial services = 0.4315 customer satisfaction+ 0.4315 number of self-service machines serving the three rural areas + 0.137 public welfare donations, the greater the value represents the deeper the depth of financial services of rural financial institutions [12]. After that, Table 4 can be obtained, and the Matlab program can be used to calculate the results of the weights obtained as shown in Table 4, and the completion of the dual target balance degree of the calendar year is shown in Table 5.

TABLE 3. DATA OF SHANGHAI AGRICULTURAL AND COMMERCIAL BANK ON FACTORS INFLUENCING THE BALANCE OF DUAL OBJECTIVES

Year	Rate of return on capital （‰）	Cost to income ratio （%）	Percentage of loans related to agriculture （%）	Breadth of financial services （Piece）	Depth of financial services （%）
2010	0.96	44	27.67	220	401
2011	1.13	38.76	29.63	226	405
2012	1.14	37.75	27.16	228	581
2013	1.08	38.33	24.85	239	644
2014	1.08	38.17	23.26	245	800
2015	1.06	35.13	20.78	247	753
2016	0.94	37.38	17.85	245	729
2017	0.90	33.8	17.95	242	750
2018	0.93	32	11.97	239	606
2019	0.98	30.37	10.92	236	714

TABLE 4. WEIGHTING STATISTICS FOR SHANGHAI AGRICULTURAL AND COMMERCIAL BANK

Indicators	AHP weighting	Entropy weighting	Combined weights
A1	0.3835	0.0141	0.1988
A2	0.0891	0.6930	0.3910
A3	0.3978	0.1897	0.2937
A4	0.0850	0.0029	0.0440
A5	0.0446	0.1004	0.0725

TABLE 5. RANKING RESULTS OF TOPSIS METHOD OF SHANGHAI AGRICULTURAL AND COMMERCIAL BANK

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Relative Proximity	0.071	0.101	0.109	0.099	0.100	0.114	0.087	0.111	0.101	0.107
Sort by	10	5	3	8	7	1	9	2	6	4

3.3Results of TOPSIS model based on AHP and entropy weight method

The data of China Agricultural Development Bank collated after data pre-processing is shown in Table 6, and then using the Matlab program and the comprehensive weights obtained from the hierarchical analysis method and entropy weight method above, we can get the results of the weights of each influencing factor of the dual objectives of China Agricultural Development Bank as shown in Table 7, and the completion of the dual objectives balance in the calendar year is shown in Table 8.

TABLE 6. CHINA AGRICULTURAL DEVELOPMENT BANK DATA ON FACTORS INFLUENCING DUAL TARGET BALANCE

Year	**Rate of return on capital（‰）**	**Cost to income ratio（%）**	**Percentage of loans related to agriculture（%）**	**Breadth of financial services（Piece）**	**Depth of financial services（%）**
2015	2.70	28.06	94.70	318	99.96
2016	2.61	26.74	94.98	318	99.86
2017	2.62	27.39	97.57	313	99.99
2018	2.74	30.08	98.04	308	99.97
2019	3.13	30.48	98.47	305	99.99

TABLE 7. RESULTS OF WEIGHTING STATISTICS OF CHINA AGRICULTURAL DEVELOPMENT BANK

Indicators	**AHP weighting**	**Entropy weighting**	**Combined weights**
A1	0.3835	0.0048	0.1942
A2	0.0891	0.8158	0.4527
A3	0.3978	0.0003	0.1991
A4	0.0850	0.0003	0.0427
A5	0.0446	0.1789	0.1118

TABLE 8. RANKING RESULTS OF TOPSIS METHOD OF CHINA AGRICULTURAL DEVELOPMENT BANK

Year	2015	2016	2017	2018	2019
Relative Proximity	0.056	0.061	0.266	0.306	0.313
Sort by	5	4	3	2	1

4 CONCLUSION

From the Annual Report and Social Responsibility Report of the two banks, it can be seen that the economic volume of China Agricultural Development Bank is much larger than that of Shanghai Agricultural and Commercial Bank. In addition, as a policy bank, China Agricultural Development Bank has done a good job in terms of social objectives, and the ratio of agriculture-related loans is generally above 90%, which is also higher than that of Shanghai Agricultural and Commercial Bank, an ordinary rural financial institution.

First of all, based on the expert scoring method, the factors influencing the dual-objective balance of rural financial institutions calculated by the subjective hierarchical analysis method are, in descending order, the proportion of agriculture-related loans, capital return rate, cost-income ratio, breadth of financial services, and depth of financial services. The result is that both banks use the entropy method to calculate the result that the weight of cost-income ratio is higher than that of capital return rate and other influencing factors. Secondly, the weights obtained from the two methods are set, and the weights of each influencing factor are cost-to-income ratio, agricultural-related loans, return on capital, depth of financial services, and breadth of financial services in order. Finally, this paper substitutes the integrated weights into TOPSIS analysis method, and after analyzing the ten-year data of Shanghai Agricultural and Commercial Bank, we get that the best performance of the bank's dual target-by-goal balance is in 2015, and the worst is in 2010, and the overall trend of positive development first and then reverse development. In contrast, China Agricultural Development Bank's dual target completion in the past five years is gradually improving, with the best in 2019 and the worst in 2015.

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