

Enterprise Credit Risk Assessment Based on Hybrid Fuzzy Synthetic Evaluation Model

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Abstract This article uses a hybrid fuzzy synthetic evaluation model to evaluate the credit risk of Shouguang vegetable enterprises, and designs four risk levels: impact degree, occurrence probability, risk manageability and government support level. The model uses average score technology to calculate the scores of secondary indicators, primary indicators and evaluation targets at each level, uses sorting technology to sort secondary indicators and primary indicators at each level, and uses fuzzy synthetic evaluation technology to construct Shouguang enterprise credit risk evaluation. The model uses the geometric mean method to calculate the comprehensive score, and summarizes the comprehensive score results to make decisions. Among them, the data in this article comes from a questionnaire, which was completed by a total of 41 professionals who have a better understanding of the credit risks of Shouguang vegetable companies. Through calculation, the comprehensive credit risk score of Shouguang Vegetable Enterprise is 2.8585. The risk is medium risk. Banks can lend based on the operation of specific enterprises. The calculation results also show that the risk assessment results at different levels are not completely consistent. The main first-level risk indicators at the first three levels are "enterprise technological innovation" and "enterprise financial status", and the main first-level risk indicators at the last level are "Enterprise management level" and "enterprise development plan". Indicators related to corporate technological innovation and financial status are the main influencing indicators of the credit risk of Shouguang vegetable companies.

Keywords: Hybrid fuzzy synthetic evaluation, average score technology, ranking technology, corporate credit risk covid-19 post-vaccination, fuzzy cognitive maps, neutrosophic cognitive maps, neutrosophic set.

Introduction

With the development of the vegetable industry, Shouguang vegetable enterprises play an important role in ensuring full employment and optimizing the economic structure [1]. Shouguang vegetable enterprises are the main force in promoting local economic development. However, due to their weak foundation, generally small scale, unstable production and operation, etc., their credit risks are also uncertain, which leads to difficulties in bank loans [2].

Corporate credit risk is an important risk that banks must consider. It mainly refers to the risk that the company fails to perform the contract during the loan process, causing economic losses to the bank [3]. In order to solve the problem of bank loan difficulties, enterprises must establish a credit risk management system, establish a good credit concept, effectively prevent potential credit risks, and introduce third-party evaluation agencies to conduct credit evaluation [4].

Credit issues are the key issue in solving bank loans for small and medium-sized enterprises. Objective and accurate evaluation of credit risks is of great significance to Shouguang vegetable enterprises and lending banks [5]. Therefore, this article takes Shouguang Vegetable Enterprise as an example, and on the basis of fully considering the characteristics of the enterprise, constructs a hybrid fuzzy comprehensive evaluation model of the credit risk of Shouguang Vegetable Enterprise, objectively and accurately evaluates loan enterprises, and provides decision-making basis for enterprises and banks.

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Literature Review

1. Enterprise credit risk evaluation index system

Some Different types of enterprise evaluation indicators are different. For example, intellectual property enterprises can construct an enterprise evaluation index system from five aspects: enterprise attributes, intellectual property dynamic information, regulatory information, enterprise capabilities, and social evaluation [6], listed companies in the agriculture, forestry, animal husbandry and fishery sectors can establish a credit risk evaluation index system from financial and macroeconomic aspects [7]. Technology-based companies need to consider debt solvency, profitability, Operating capabilities, development capabilities, cash flow levels, R&D capabilities and corporate governance structure [8], etc.

The research object in this article is the credit risk of Shouguang vegetable enterprises. Building a scientific and reasonable evaluation index system is the prerequisite for accurate evaluation. See Section 4 for the specific indicator system.

2. Enterprise credit risk assessment

There are rich research results on corporate credit risk evaluation models. The main models include: using the AEN-logistic model [9], RF-LSMA-SVM model [10-11], quadratic weighted TOPSIS model [12] and fuzzy analytic hierarchy process model [13] to assess the credit risk of Chinese small and medium-sized enterprises, using ETCRA The model [14] evaluates the credit risk of small and micro enterprises in Lithuania, and uses the RF-WNB model [15] to evaluate the credit risk of enterprises from the perspective of supply chain ,etc.

This paper integrates average score technology, ranking technology and fuzzy synthetic evaluation technology to construct a hybrid fuzzy synthetic evaluation model to conduct evaluation research on the credit risk of Shouguang vegetable enterprises.

3. Fuzzy synthetic evaluation model

The theoretical basis of fuzzy synthetic evaluation is fuzzy sets, which takes things that cannot be accurately determined as research goals and uses membership functions to express the degree of compatibility between elements and sets. When making a multi-factor evaluation of things, it is necessary to consider many influencing factors at different levels, and a fuzzy synthetic evaluation model can be used. The application of fuzzy synthetic evaluation model is very wide, mainly including: using FSEM to evaluate the risks of public-private partnership power projects in Ghana [16], using fuzzy synthetic evaluation and genetic algorithm to evaluate customer satisfaction of Iranian tourism website [17], using the fuzzy synthetic evaluation (FSE) method to evaluate climate hazards [18], using the fuzzy synthetic evaluation model (FSE) to evaluate the health and safety of the Malaysian construction industry Safety practice [19], using improved fuzzy synthetic evaluation method to evaluate the sustainability of hybrid energy systems [20], etc.

Materials and Methods

The hybrid fuzzy synthetic evaluation (HFSE) model is an evaluation technology that integrates scoring technology, ranking technology and fuzzy synthetic evaluation technology to make accurate evaluations of targets. The main differences between this study and previous fuzzy synthetic evaluation models are (1) combining scoring technology and ranking technology with fuzzy synthetic evaluation technology; (2) setting up evaluation groups in the evaluation set and making decisions for all evaluation groups. Judgment; (3) Use questionnaires to survey professionals from relevant companies and use survey data to calculate. This section mainly introduces the process of the hybrid fuzzy synthetic evaluation model.

1. Construct an evaluation index system for the target and determine the set of evaluation factors

Fully analyze the influencing factors of the target, determine the main evaluation indicators, construct an appropriate hierarchical structure, and make an evaluation structure diagram based on the target layer and indicator layer (first-level indicators, second-level indicators, etc.). Usually, the evaluation index system reaches the second-level indicators, and a few can reach the third-level indicators. The effect of fuzzy synthetic evaluation will be greatly reduced when it reaches the fourth-level indicators and above.

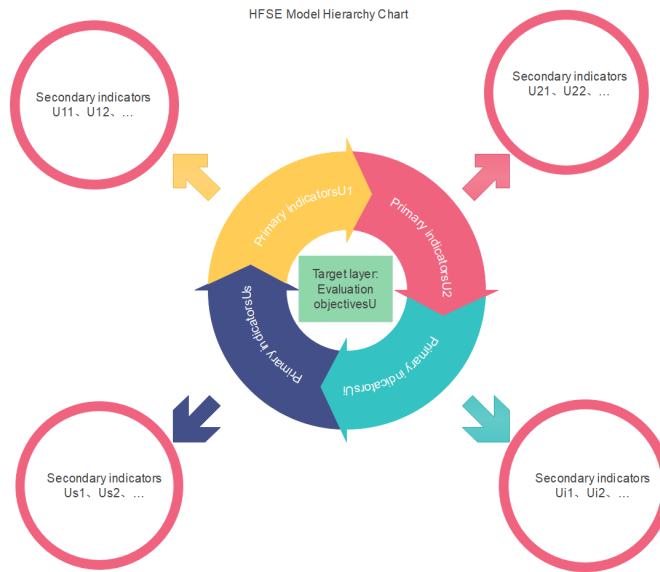


Figure 1. Evaluation structure diagram of hybrid fuzzy synthetic evaluation model

The evaluation factor set U is constructed according to the lowest level index of the evaluation index system, as follows:

$$\begin{aligned}
 U &= \{U_1, U_2, \dots, U_s\} \\
 &= \{U_{11}, U_{12}, \dots, U_{1t_1}, U_{21}, U_{22}, \dots, U_{2t_2}, \dots, U_{s1}, U_{s2}, \dots, U_{st_s}\} \\
 &= \{L\}
 \end{aligned}$$

2. Construct an evaluation group and determine the judgment set of the evaluation group

An evaluation group is constructed according to the process or level of the evaluation target, and each evaluation group determines the same number of evaluation levels. See Table 1 for details.

Table 1. List of evaluation groups and their evaluation levels

| Judgment set | Evaluation team | Rating |
|--------------|-----------------|---------------------------------|
| V | V_1 | $V_{11}, V_{12}, \dots, V_{1n}$ |
| | V_2 | $V_{21}, V_{22}, \dots, V_{2n}$ |
| | ... | ... |
| | V_m | $V_{m1}, V_{m2}, \dots, V_{mn}$ |

Note: The value of m is generally between 2-9

3. Prepare questionnaires and collect evaluation data

Based on the target's evaluation factor set and evaluation group information, prepare a scale questionnaire, conduct on-site surveys of business professionals, summarize the survey data, conduct reliability analysis, and draw frequency tables.

4. Calculate relevant parameters of secondary indicators

In two steps, the secondary indicators membership degree is first calculated, and then the secondary indicators score is calculated and ranked.

(1) Calculate the membership degree of secondary indicators

In two steps, the secondary indicators membership degree is first calculated, and then the secondary indicators score is calculated and ranked.

Calculation formula:

$$MF_W^{(*)} = \frac{f_W^{(*)} / \sum_{i=1}^n f_W^{(*)}}{V_W^{(*)}} + \frac{f_{V2}^{(*)} / \sum_{i=1}^n f_W^{(*)}}{V_{V2}^{(*)}} + L + \frac{f_{Vt}^{(*)} / \sum_{i=1}^n f_W^{(*)}}{V_{Vt}^{(*)}}$$

$$= (Mf_W^{(*)}, Mf_{V2}^{(*)}, L, Mf_{Vt}^{(*)}) \tag{1}$$

Among them, MF represents the membership function, $Mf_{Vj}^{(*)} = f_{Vj}^{(*)} / \sum_{i=1}^n f_W^{(*)}$, $f_{Vj}^{(*)}$ represents the frequency of the secondary indicator U_W belonging to the j th level under the evaluation group $*$, and $\sum_{i=1}^n f_W^{(*)}$ is equal to the total number of valid questionnaires collected.

(2) Calculate the secondary indicator scores and rank them

Score calculation formula:

$$MS_W^{(*)} = \sum_{i=1}^n i * Mf_W^{(*)} \tag{2}$$

Among them, MF represents the mean score, $Mf_W^{(*)}$ represents the membership value of the secondary indicators U_W belonging to the i -th level under the evaluation group $*$, and i represents the i -th level of the secondary indicator U_W under the evaluation group

In two steps, the secondary indicators membership degree is first calculated, and then the secondary indicators score is calculated and ranked.

5. Calculate indicator weight

The weights of the secondary indicators and primary indicators are calculated based on the scores of each indicator. The specific process is as follows

(1) Calculate the weight of secondary indicators

Calculation formula:

$$w_{ij}^{(*)} = \frac{MS_{ij}^{(*)}}{\sum_{k=1}^{t_i} MS_{ik}^{(*)}} \tag{3}$$

Among them, $MS_{ij}^{(*)}$ represents the mean score of secondary indicator U_{ij} under evaluation group $*$

(2) Calculate the weight of Primary indicators

Calculation formula:

$$w_i^{(*)} = \frac{\sum_{j=1}^{t_i} MS_{ij}^{(*)}}{\sum_{i=1}^s \sum_{j=1}^{t_i} MS_{ij}^{(*)}} \tag{4}$$

Among them, $\sum_{j=1}^{t_i} MS_{ij}^{(*)}$ represents the sum of the scores of all secondary indicators under the evaluation group U_i for the first-level indicator U_i .

6. Calculate comprehensive evaluation results

(1) Calculate the membership degree of primary indicators

Calculation formula:

$$MF_l^{(*)} = (W_l^{(*)})_{1 \times t_l} \times (A_{MF_l}^{(*)})_{t_l \times n} = (Mf_{l_1}^{(*)}, Mf_{l_2}^{(*)}, \dots, Mf_{l_n}^{(*)}) \tag{5}$$

Among them, $(W_l^{(*)})_{1 \times t_l}$ represents the weight vector $(w_{l_1}^{(*)}, w_{l_2}^{(*)}, \dots, w_{l_{t_l}}^{(*)})$ of the primary indicators U_l under the evaluation group U_i , and $(A_{MF_l}^{(*)})_{t_l \times n}$ represents the membership matrix (judgment matrix) of the primary indicators U_l under the evaluation group U_i .

(2) Calculate the primary indicators scores and rank them

Calculation formula:

$$MS_l^{(*)} = \sum_{i=1}^n i * Mf_{li}^{(*)} \tag{6}$$

Among them, $Mf_{li}^{(*)}$ represents the membership value of the primary indicators U_l belonging to the i -th level under the evaluation group U_i .

(3) Calculate target membership degree

$$MF^{(*)} = (W^{(*)})_{1 \times s} \times (A_{MF}^{(*)})_{s \times n} = (Mf_1^{(*)}, Mf_2^{(*)}, \dots, Mf_n^{(*)}) \tag{7}$$

Among them, $(W^{(*)})_{1 \times s}$ represents the weight vector $(w_1^{(*)}, w_2^{(*)}, \dots, w_s^{(*)})$ of target U under evaluation group U_i , and $(A_{MF}^{(*)})_{s \times n}$ represents the membership matrix (judgment matrix) of target U under evaluation group U_i .

(4) Calculate target score

Calculation formula:

$$MS^{(*)} = \sum_{i=1}^n i * Mf_i^{(*)} \tag{8}$$

Among them, $Mf_i^{(*)}$ represents the membership value of target U belonging to the i th level under evaluation group $*$.

(5) Use geometric mean method to calculate comprehensive score and rank

Calculation formula:

$$MS = \sqrt[m]{MS^{(v_1)} * MS^{(v_2)} * L * MS^{(v_m)}} \tag{9}$$

(6) Use the arithmetic average method to calculate the overall score and rank

Calculation formula:

$$MS' = \frac{MS^{(v_1)} + MS^{(v_2)} + L + MS^{(v_m)}}{m} \tag{10}$$

(7) Calculate the mean and variance to determine the final comprehensive score

Calculate the mean and variance of the comprehensive score under the geometric mean method and the arithmetic mean method, and select the final comprehensive score calculation formula and result based on the mean and variance.

Hybrid Fuzzy Synthetic Evaluation of Credit Risk of Shouguang Vegetable Enterprises

1. Construct a credit risk evaluation index system for Shouguang vegetable enterprises and determine the set of evaluation factors

By reviewing the literature, the credit risk evaluation indicators of Shouguang vegetable enterprises were summarized, and an evaluation index system including targets, first-level indicators (6), and second-level indicators (30) was constructed (Table 2). The Shouguang vegetable enterprise credit risk evaluation factor set consists of secondary indicators in the indicator system (Figure 2).



Figure 2. Shouguang vegetable enterprise credit risk evaluation factor set

Table 2. Shouguang vegetable enterprise credit risk evaluation index system

| Target | Primary indicators | Secondary indicators | Literature |
|--|---|--|-----------------|
| Shouguang Vegetable Enterprise Credit Risk Assessment U | Enterprise financial position U1 | Lack of professional financial personnel U11 | [26][28] |
| | | Financial personnel lack work experience U12 | [26][28] |
| | | Imbalance between income and expenditure U13 | [21-23] |
| | | Lack of investor funding support U14 | [22-24][26] |
| | | Poor cash flow U15 | [21][23] |
| | Enterprise development planning U2 | Unclear development goals U21 | [26][28] |
| | | Inaccurate development positioning U22 | [24] |
| | | Delayed marketing and sales planning U23 | [21][25-26][28] |
| | | No corporate culture formed U24 | [28] |
| | | The prospects for sustainable development are not optimistic U25 | [26][28] |
| | Enterprise management level U3 | The scale of the enterprise is relatively small U31 | [22][28] |
| | | Lack of experience among management personnel U32 | [22][27-28] |
| | | Insufficient professional knowledge of employees U33 | [26][28] |
| | | The actual controller's management level is not high U34 | [22][27-28] |
| | | Unreasonable management structure U35 | [25][27] |
| | Enterprise technological innovation U4 | Lack of technical innovation personnel U41 | [28] |
| | | Low enthusiasm for technological innovation U42 | [28] |
| | | Low investment in technological innovation funds U43 | [28] |
| | | Low level of technical research and development personnel U44 | [28] |
| | | Low number of patent authorizations U45 | [28] |
| | Enterprise survival environment U5 | Industry development is sluggish U51 | [21-22][25][28] |
| | | Low level of regional economic development U52 | [21][25][27-28] |
| | | Poor network environment U53 | [28] |
| | | Enterprise location difference U54 | [27] |
| High level of economic inflation U55 | | [25][28] | |
| Enterprise cooperation level U6 | Lack of cooperation with supply enterprises U61 | [21][28] | |
| | Lack of cooperation with sales platforms U62 | [21][28] | |
| | Few cooperation projects with universities U63 | [28] | |
| | Few technical cooperation projects with research institutes U64 | [28] | |
| | Few cooperation projects with local governments U65 | [21][27] | |

2. Construct a Shouguang vegetable enterprise credit risk evaluation team and determine the evaluation team's judgment set

The credit of Shouguang vegetable enterprises will have a risk impact on its evaluation indicators at the levels of impact, risk occurrence probability, risk manageability and government support. This study constructed a risk assessment group based on the above four levels and determined the judgment set. See Table 3 for details.

Table 3. Shouguang vegetable enterprise credit risk assessment group and its judgment set

| Target | Evaluation team | Rating |
|--|--------------------------------|---|
| Shouguang Vegetable Enterprise Credit Risk Assessment | Impact level(I) | very low, low, medium, high, very high |
| | Probability of occurrence(P) | Below 20%, 20%-40%, 40%-60%, 60%-80%, above 80% |
| | Manageability of risk(M) | Very easy to manage, easy to manage, able to manage, relatively difficult to manage, very difficult to manage |
| | Support level of government(S) | Government support is very strong, government support is relatively large, government support is average, government support is relatively small, and government support is not available |

3. Conduct a questionnaire survey on relevant personnel of Shouguang vegetable enterprises and collect data

The questionnaire is designed to collect opinions from experts and professionals who have knowledge of the credit risks of Shouguang vegetable companies and consists of three parts. The first part is the basic information of the respondents, including age, years of working in the company, and understanding of corporate credit risks, etc. The second part is the secondary indicator scale, which uses an ordinal scale to evaluate the risk levels of secondary indicators at four levels. The third part is to investigate the company information and investigation location.

This study first invited 1 bank credit staff, 2 Shouguang vegetable enterprise managers and 4 management experts from Weifang University of Science and Technology to participate in the questionnaire survey to verify the questionnaire and adjust the questionnaire based on feedback. After the revision, questionnaires will be distributed one-on-one to relevant personnel (relevant university researchers, corporate staff, bank staff, etc.) through WeChat, email, links, etc. for testing, and the questionnaires will be collected. From November 3rd to 4th, 2023, a total of 50 online questionnaires were distributed through WeChat and Email to colleagues, corporate friends, bank friends, etc., and 41 valid questionnaires were actually recovered, with an effective rate of 82%. Survey data analysis (The specific analysis is shown in Appendix 1) as follows:

(1) 43.9% of the respondents have more than 5 years of working experience in vegetable companies and are relatively familiar with Shouguang vegetable companies. 46.3% of the respondents are professional and technical personnel from universities and are relatively familiar with corporate credit risk knowledge. Show that the survey data is credible.

(2) Use the software SPSS24 to conduct reliability analysis on the questionnaire data. It can be found that the values of Cronbach's alpha are all >0.8, which is considered to be highly reliable. Therefore, the reliability of the questionnaire is very good and is suitable for continued analysis.

4. Calculate the credit risk parameters of Shouguang vegetable enterprises

The specific calculation process of the credit risk parameters of Shouguang Vegetable Enterprise is shown in Appendix 2. This article directly gives the results, as follows:

(1) Secondary indicators membership degree

Use formula (1) to calculate the membership degree of the Secondary indicators of credit risk of Shouguang vegetable enterprises. The results are shown in Figure 3.1-3.4.

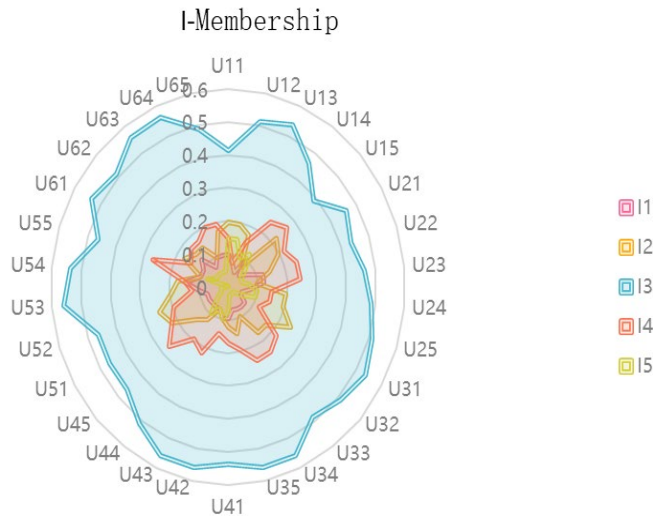


Figure 3.1. Secondary indicator membership degree under the Impact level(I)

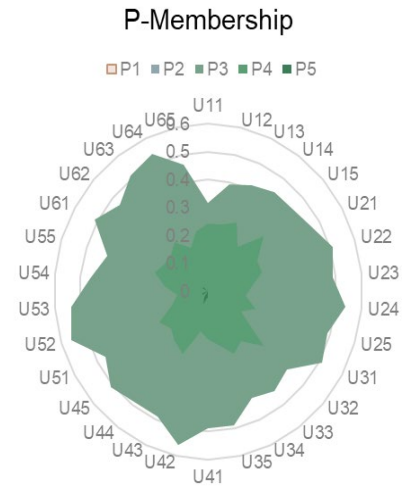


Figure 3.2. Secondary indicator membership degree under Probability of occurrence(P)

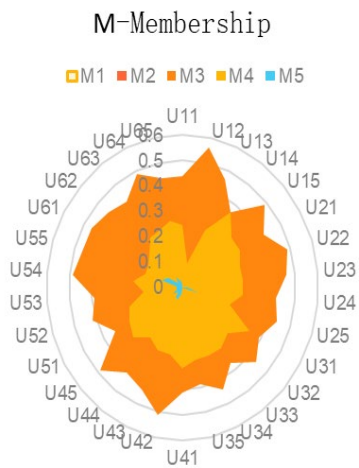


Figure 3.3. Secondary indicator membership degree under Manageability of risk(M)

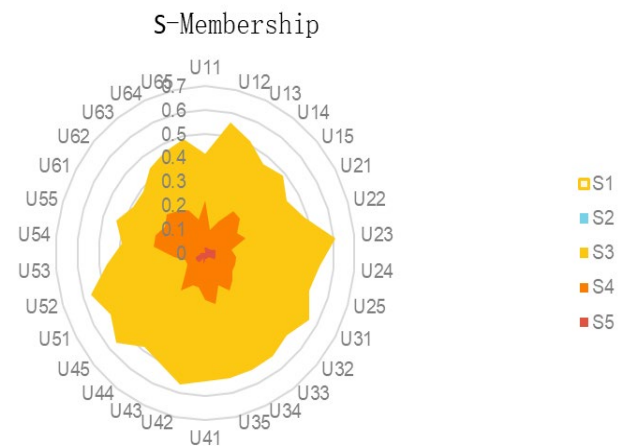


Figure 3.4. Secondary indicator membership degree under Support level of government(S)

(2) Secondary indicator scores and rankings

Use formula (2) to calculate the risk score of the Secondary indicator of credit risk of Shouguang vegetable enterprises and rank them. The results are shown in Table 4.

Table 4. Shouguang vegetable enterprise credit risk secondary indicator risk score and ranking

| Code | I-scores | I-rankings | P-scores | P-rankings | M-scores | M-rankings | S-scores | S-rankings |
|------|----------|------------|----------|------------|----------|------------|----------|------------|
| U11 | 3.0488 | 8 | 2.7561 | 24 | 2.8293 | 27 | 2.8049 | 16 |
| U12 | 3.0244 | 13 | 2.7561 | 24 | 2.7317 | 29 | 2.7073 | 29 |
| U13 | 3.0732 | 6 | 2.8293 | 9 | 2.8537 | 23 | 2.7561 | 24 |
| U14 | 3.2195 | 1 | 2.8780 | 4 | 3.0000 | 4 | 2.8537 | 11 |
| U15 | 3.0976 | 5 | 2.9024 | 2 | 2.9756 | 7 | 2.8780 | 8 |
| U21 | 2.9756 | 17 | 2.7805 | 18 | 2.9024 | 17 | 2.7561 | 24 |
| U22 | 2.9512 | 20 | 2.8293 | 9 | 2.8780 | 19 | 2.9268 | 2 |
| U23 | 3.0488 | 8 | 2.7805 | 18 | 2.8780 | 19 | 2.9024 | 4 |
| U24 | 3.0000 | 14 | 2.7073 | 27 | 2.9024 | 17 | 2.8780 | 8 |
| U25 | 3.0488 | 8 | 2.8293 | 9 | 3.0000 | 4 | 2.8537 | 11 |
| U31 | 2.8780 | 25 | 2.7073 | 27 | 2.9756 | 7 | 2.9024 | 4 |
| U32 | 2.9512 | 20 | 2.9024 | 2 | 2.8780 | 19 | 2.8293 | 14 |
| U33 | 2.9756 | 17 | 2.7805 | 18 | 2.8537 | 23 | 2.9024 | 4 |
| U34 | 3.0488 | 8 | 2.8780 | 4 | 2.9268 | 14 | 2.7805 | 20 |
| U35 | 2.9512 | 20 | 2.7805 | 18 | 2.8780 | 19 | 2.9512 | 1 |
| U41 | 3.0000 | 14 | 2.8049 | 14 | 2.9512 | 9 | 2.9024 | 4 |
| U42 | 3.0488 | 8 | 2.8049 | 14 | 3.0244 | 2 | 2.8780 | 8 |
| U43 | 3.1463 | 2 | 3.0000 | 1 | 3.0244 | 2 | 2.7561 | 24 |
| U44 | 3.1220 | 3 | 2.8780 | 4 | 2.9512 | 9 | 2.9268 | 2 |
| U45 | 3.0732 | 6 | 2.7805 | 18 | 3.0488 | 1 | 2.8293 | 14 |
| U51 | 2.9024 | 24 | 2.8537 | 8 | 2.9268 | 14 | 2.7317 | 28 |
| U52 | 2.8537 | 28 | 2.8049 | 14 | 2.8537 | 23 | 2.8049 | 16 |
| U53 | 2.7805 | 29 | 2.6098 | 30 | 2.6098 | 30 | 2.7073 | 29 |
| U54 | 2.6829 | 30 | 2.6829 | 29 | 2.8537 | 23 | 2.8049 | 16 |
| U55 | 3.1220 | 3 | 2.7561 | 24 | 3.0000 | 4 | 2.8537 | 11 |
| U61 | 2.8780 | 25 | 2.8780 | 4 | 2.9268 | 14 | 2.8049 | 16 |
| U62 | 2.8780 | 25 | 2.8049 | 14 | 2.8049 | 28 | 2.7805 | 20 |
| U63 | 2.9756 | 17 | 2.8293 | 9 | 2.9512 | 9 | 2.7805 | 20 |
| U64 | 3.0000 | 14 | 2.8293 | 9 | 2.9512 | 9 | 2.7805 | 20 |
| U65 | 2.9268 | 23 | 2.7805 | 18 | 2.9512 | 9 | 2.7561 | 24 |

(3) Secondary indicator weight

Use formula (3) to calculate the weight of the secondary indicator of credit risk of Shouguang vegetable enterprises. The results are shown in Figure 4.

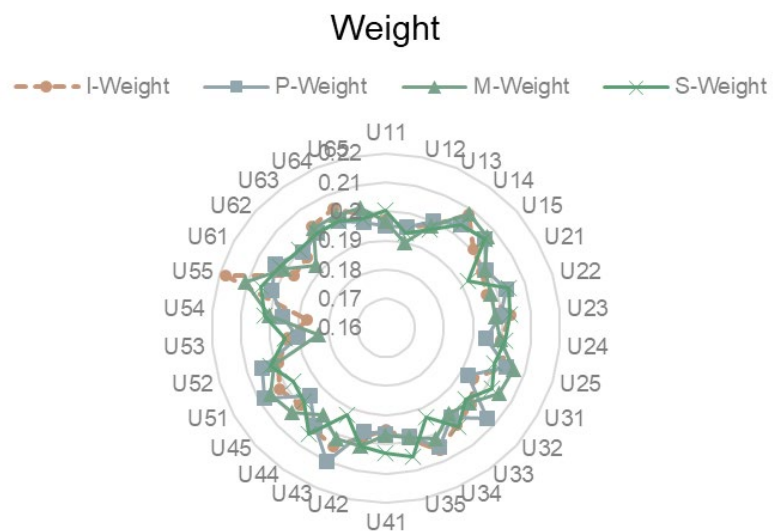


Figure 4. Weight of secondary indicators of credit risk of Shouguang vegetable enterprises

(4) Primary indicators weight

Use formula (3) to calculate the weight of the primary indicators of credit risk of Shouguang vegetable enterprises. The results are shown in Table 5.

Table 5. Weight of the primary indicators of credit risk of Shouguang vegetable enterprises

| Code | I-Weight | P-Weight | M-Weight | S-Weight |
|------|----------|----------|----------|----------|
| U1 | 0.1724 | 0.1677 | 0.1649 | 0.1651 |
| U2 | 0.1675 | 0.1654 | 0.1668 | 0.1689 |
| U3 | 0.1651 | 0.1669 | 0.1662 | 0.1694 |
| U4 | 0.1716 | 0.1695 | 0.1718 | 0.1686 |
| U5 | 0.1599 | 0.1628 | 0.1632 | 0.1640 |
| U6 | 0.1634 | 0.1677 | 0.1671 | 0.1640 |

(5) Primary indicators membership degree

Use formula (5) to calculate the Primary indicators membership degree of credit risk of Shouguang vegetable enterprises. The results are shown in Figure 5.1-5.4.

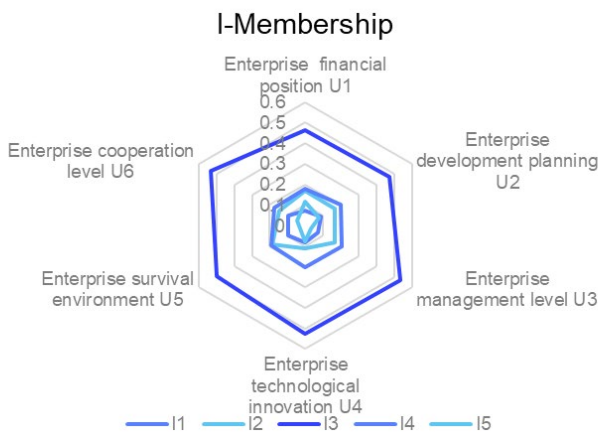


Figure 5.1. Primary indicator membership degree under the Impact level(I)

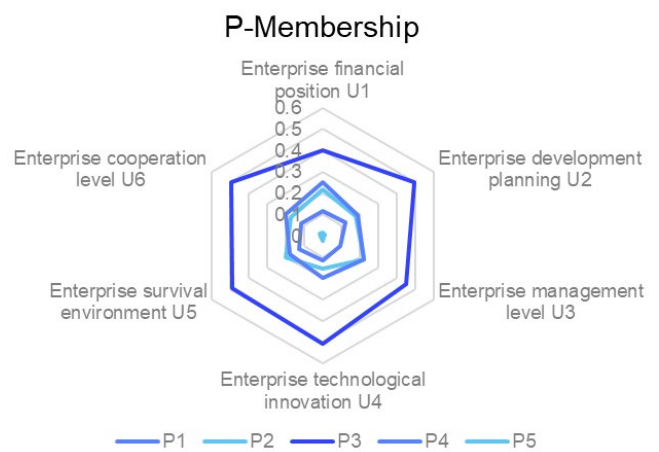


Figure 5.2. Primary indicator membership degree under Probability of occurrence(P)

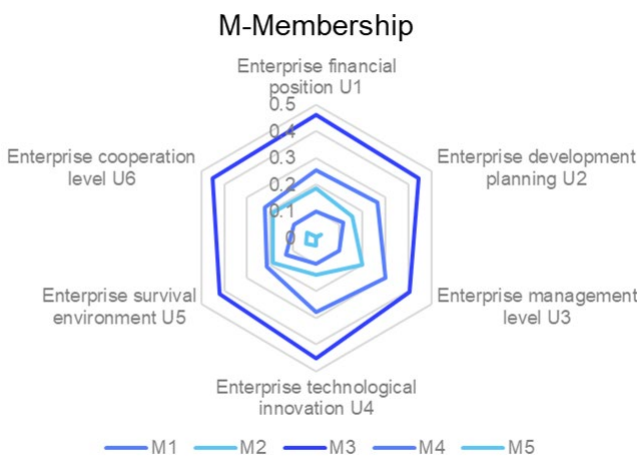


Figure 5.3. Primary indicator membership degree under Manageability of risk(M)

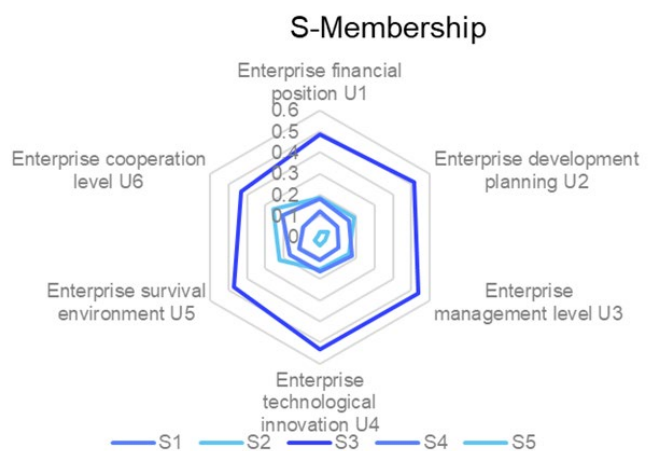


Figure 5.4. Primary indicator membership degree under Support level of government(S)

(6) Primary indicators scores and rankings

Use formula (6) to calculate the Primary indicators score of credit risk of Shouguang vegetable enterprises and rank the weights. The results are shown in Table 6.

Table 6. Shouguang vegetable enterprise credit risk primary indicators risk score and ranking

| Code | I-scores | I-rankings | P-scores | M-scores | M-rankings | S-scores | S-rankings |
|------|----------|------------|----------|----------|------------|----------|------------|
| U1 | 3.0942 | 1 | 2.8257 | 2.8814 | 5 | 2.8014 | 4 |
| U2 | 3.0054 | 3 | 2.7861 | 2.9129 | 3 | 2.8646 | 2 |
| U3 | 2.9620 | 4 | 2.8116 | 2.9031 | 4 | 2.8744 | 1 |
| U4 | 3.0789 | 2 | 2.8559 | 3.0006 | 1 | 2.8598 | 3 |
| U5 | 2.8758 | 6 | 2.7442 | 2.8548 | 6 | 2.7815 | 5 |
| U6 | 2.9326 | 5 | 2.8248 | 2.9182 | 2 | 2.7806 | 6 |

(7) Shouguang Vegetable Enterprise Credit Risk membership degree

Use formula (7) to calculate the credit risk membership degree of Shouguang vegetable enterprises. The results are shown in Table 7.

Table 7. Shouguang vegetable enterprise credit risk membership degree

| Target layer | Code | Membership | | | | |
|-----------------------------------|--------|------------|--------|--------|--------|--------|
| | | I1 | I2 | I3 | I4 | I5 |
| Enterprise Credit Risk Assessment | U | 0.0842 | 0.1568 | 0.5037 | 0.1918 | 0.0635 |
| | | P1 | P2 | P3 | P4 | P5 |
| | | 0.1161 | 0.1913 | 0.4738 | 0.2056 | 0.0132 |
| | | M1 | M2 | M3 | M4 | M5 |
| | | 0.1161 | 0.1913 | 0.4738 | 0.2056 | 0.0132 |
| | | S1 | S2 | S3 | S4 | S5 |
| 0.1064 | 0.1927 | 0.4972 | 0.1743 | 0.0294 | | |

(8) Calculate target score

Use formula (8) to calculate the credit risk score of Shouguang vegetable enterprises. The results are shown in Table 8.

Table 8. Shouguang vegetable enterprise credit risk score

| Target layer | Code | I-score | P-score | M-score | S-score |
|-----------------------------------|------|---------|---------|---------|---------|
| Enterprise Credit Risk Assessment | U | 2.9935 | 2.8085 | 2.8085 | 2.8276 |

(9) Comprehensive score and ranking

Use formula (8) and formula (9) respectively to calculate the comprehensive credit risk score of Shouguang vegetable enterprises, rank them, and compare the mean and variance. The results are shown in Tables 9.1-9.3

Table 9.1. Comprehensive score, ranking and mean variance of secondary indicators of credit risk of Shouguang vegetable enterprises

| Code | Geometric mean method | Overall score ranking 1 | Mean 1 | Arithmetic mean | Overall score ranking 2 | Mean 2 |
|------|-----------------------|-------------------------|------------|-----------------|-------------------------|------------|
| U11 | 2.8576 | 22 | 2.8814 | 2.8598 | 22 | 2.8829 |
| U12 | 2.8021 | 28 | Variance 1 | 2.8049 | 28 | Variance 2 |
| U13 | 2.8757 | 18 | 0.0042 | 2.8780 | 17 | 0.0043 |
| U14 | 2.9844 | 1 | | 2.9878 | 1 | |
| U15 | 2.9622 | 4 | | 2.9634 | 4 | |
| U21 | 2.8523 | 25 | | 2.8537 | 23 | |
| U22 | 2.8960 | 0 | | 2.8963 | 12 | |
| U23 | 2.9009 | 11 | | 2.9024 | 11 | |
| U24 | 2.8700 | 20 | | 2.8720 | 19 | |
| U25 | 2.9314 | 6 | | 2.9329 | 6 | |
| U31 | 2.8641 | 21 | | 2.8659 | 21 | |
| U32 | 2.8899 | 13 | | 2.8902 | 14 | |
| U33 | 2.8772 | 17 | | 2.8780 | 18 | |
| U34 | 2.9069 | 10 | | 2.9085 | 10 | |
| U35 | 2.8894 | 14 | | 2.8902 | 14 | |
| U41 | 2.9137 | 9 | | 2.9146 | 9 | |
| U42 | 2.9373 | 5 | | 2.9390 | 5 | |
| U43 | 2.9783 | 2 | | 2.9817 | 2 | |
| U44 | 2.9681 | 3 | | 2.9695 | 3 | |
| U45 | 2.9301 | 7 | | 2.9329 | 6 | |
| U51 | 2.8527 | 23 | | 2.8537 | 23 | |
| U52 | 2.8292 | 26 | | 2.8293 | 26 | |
| U53 | 2.6759 | 0 | | 2.6768 | 30 | |
| U54 | 2.7551 | 29 | | 2.7561 | 29 | |
| U55 | 2.9296 | 8 | | 2.9329 | 6 | |
| U61 | 2.8716 | 19 | | 2.8720 | 19 | |
| U62 | 2.8168 | 27 | | 2.8171 | 27 | |
| U63 | 2.8830 | 16 | | 2.8841 | 16 | |
| U64 | 2.8889 | 15 | | 2.8902 | 13 | |
| U65 | 2.8524 | 24 | | 2.8537 | 23 | |

Table 9.2. Comprehensive score, ranking and mean variance of the Primary indicators credit risk of Shouguang vegetable enterprises

| Code | Geometric mean method | Overall score ranking 1 | Mean 1 | Arithmetic mean | Overall score ranking 2 | Mean 2 |
|------|-----------------------|-------------------------|------------|-----------------|-------------------------|------------|
| U1 | 2.8984 | 2 | 2.8835 | 2.9007 | 2 | 2.8846 |
| U2 | 2.8912 | 3 | Variance 1 | 2.8922 | 3 | Variance 2 |
| U3 | 2.8873 | 4 | 0.0019 | 2.8878 | 4 | 0.0020 |
| U4 | 2.9473 | 1 | | 2.9488 | 1 | |
| U5 | 2.8136 | 6 | | 2.8141 | 6 | |
| U6 | 2.8633 | 5 | | 2.8640 | 5 | |

Table 9.3. Comprehensive credit risk score of Shouguang vegetable companies

| Target | Code | Geometric mean method | Arithmetic mean |
|---|------|-----------------------|-----------------|
| Shouguang Vegetable Enterprise Credit Risk Assessment | U | 2.8585 | 2.8595 |

It can be seen from the calculation results that there is not much difference between the calculation results using the geometric mean method and the arithmetic mean method, but the variance of the geometric mean method is smaller, so the geometric mean method is used to calculate the results.

Results and Findings

The evaluation results show that the credit risk of Shouguang Vegetable Enterprise is medium, with a comprehensive score of 2.8585. This result is lower than previous research [29-31], which is related to the enterprise The nature, the region where the enterprise is located, etc. are all relevant. This section focuses on the analysis of risk groups and main risk indicators.

1. Credit Risk Group Evaluation Results of Shouguang Vegetable Enterprise

(1) At the impact level (I), the credit risk score of Shouguang Vegetable Enterprise is 2.9935, with the highest score of 3.0942 for the first level indicator "Enterprise Financial Status", followed by "Enterprise Technological Innovation" (3.0789).

(2) At the probability of occurrence (P) level, the credit risk score of Shouguang Vegetable Enterprise is 2.8085, with the highest score of 2.8559 for the primary indicator "Enterprise Technology Innovation", followed by "Enterprise Financial Status" (2.8257).

(3) At the level of risk management (M), the credit risk score of Shouguang Vegetable Enterprise is 2.8085, with the highest score of 3.0006 for the first level indicator "Enterprise Technology Innovation", followed by "Enterprise Financial Status" (2.9182).

(4) At the level of government support (S), the credit risk score of Shouguang vegetable enterprises is 2.8276, with the highest score of 2.8744 for the first level indicator "enterprise management level", followed by "enterprise development planning" (2.8646).

It can be seen that the risk assessment results at different levels are not completely consistent, but the main primary risk indicators at the first three levels are "enterprise technological innovation" and "enterprise financial status", and the main primary risk indicators at the last level are "enterprise management level" and "enterprise development planning".

2. Comprehensive Credit Risk Assessment Results of Shouguang Vegetable Enterprise

In the comprehensive credit risk evaluation results of Shouguang Vegetable Enterprise, the first level indicator "Enterprise Innovation Technology" has the highest comprehensive score of 2.9473, followed by "Enterprise Financial Status" (2.8984), the third is "Enterprise Development Plan" (2.8912), the fourth is "Enterprise Management Level" (2.8873), the fifth is "Enterprise Cooperation Level" (2.8633), and the last is "Enterprise Survival Environment" (2.8136).

In the comprehensive credit risk evaluation results of Shouguang Vegetable Enterprise, the second level indicator "lack of investor financial support" has the highest comprehensive score of 2.9844, while the other 2-6 are "insufficient investment in technological innovation funds" (2.9783), "low level of technological research and development personnel" (2.9681), "poor cash flow" (2.9622), "low enthusiasm for technological innovation" (2.9373), and "pessimistic prospects for sustainable development" (2.9314).

It can be seen that indicators related to enterprise technological innovation and financial status are the main influencing indicators of enterprise credit risk, which need to be focused on.

Discussion

This paper proposes a novel corporate credit risk assessment method based on average score technology, ranking technology and fuzzy synthetic evaluation technology, and uses this technology to evaluate the credit risk of China's Shouguang vegetable companies. Compared with the fuzzy synthetic evaluation model (FSE or FCE), the hybrid fuzzy synthetic evaluation model (HFSE) has three advantages:

1. Calculation of indicator weights

Most of the traditional fuzzy synthetic evaluation models use the AHP model to calculate the index weights and use the expert evaluation method, which has a relatively large subjective impact. Different experts have different understandings, and there are great differences in the index weights. The hybrid fuzzy synthetic evaluation model uses the average score in the questionnaire data to calculate the index

weight. Since there are many investigators, the influence of subjective factors is greatly reduced, making the index weight value closer to the true value.

2. Determination of membership function

Most of the traditional fuzzy synthetic evaluation models use the triangular fuzzy membership function, and the calculated membership degrees belong to three evaluation levels. The average score technology used in the hybrid fuzzy synthetic evaluation model can extend the membership function to all evaluation levels, making the calculation results more accurate.

3. Use of judging panel

There is only one evaluation group in the traditional fuzzy synthetic evaluation model, and fuzzy evaluation can only be centralized for evaluation of different processes or different levels. The hybrid fuzzy synthetic evaluation model sets evaluation groups for different processes or levels in the evaluation set, and evaluates different evaluation groups during the investigation process, making the calculation results more accurate.

Conclusions

Bank loans are a problem faced by most enterprises and one of the main means for their survival and development. Lending to enterprises is also a bank's main business and one of its main sources of income. Therefore, enterprise credit risk assessment is the link between enterprises and banking business communication. This paper designs a hybrid fuzzy comprehensive evaluation model for the credit risk of Shouguang vegetable enterprises. Based on the average score technology, ranking technology and fuzzy synthetic evaluation, it integrates them to calculate the impact degree, occurrence probability, risk manageability and government support degree. The scores of each indicator at each level are sorted, and finally the geometric mean method is used to calculate the comprehensive evaluation results. The results are objective and accurate, and the model can be promoted and applied to provide reference for later research.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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