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Enterprise Risk Assessment of Agricultural Supply Chain Based on CRITIC- Entropy Weight -VIKOR Model

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ABSTRACT

Agriculture is the primary industry which plays a foundational role in our national economy. It is the most essential material production department. Agricultural supply chain management can ensure the safety of food production, protect the rights and interests of consumers, improve the operational efficiency of the agricultural supply chain, and increase the income of agricultural enterprises and farmers. Therefore, the key link of agricultural supply chain risk management is identifying and evaluating the risk. To improve the scientific merit and accuracy of enterprise risk assessment in the agricultural supply chain, this study constructed a risk assessment model integrating CRITIC, entropy weight and VIKOR method. It proposed five first-level indexes, including policy environment risk, market environment risk, policy adjustment risk, consumer demand change risk and natural change risk. Based on the index system, composed of 17 secondary indexes, the risk index weights of agricultural supply chain enterprises were determined jointly by the CRITIC and entropy weight methods. VIKOR method was used to carry out a risk assessment on 15 agricultural supply chain enterprises in an agricultural economic development zone. The results show that the evaluation index system of enterprise risk of agricultural supply chain proposed in this study is more scientific and reasonable. The CRITIC indicators of X-1-1, X-5-1, and X-5-2 have the largest weight. The entropy weight of X-5-1, X-5-2 and X-1-2 is the largest. The critical-entropy weight-VIKOR model can effectively distinguish the risk degree of different agricultural supply chain enterprises and provide decision support for enterprises to formulate targeted risk management countermeasures. The research results of this study are of great value for the scientific and accurate risk assessment of enterprises in the high agricultural supply chain, improving the effectiveness of risk management, enriching the methods and tools of risk assessment research in the agricultural supply chain, and realizing the safe and stable operation of the agricultural supply chain.

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1. Introduction

With the development of the social economy, people's demand and quality requirements for agricultural products continue to increase. However, due to the cyclical, regional and natural constraints of agricultural production, the supply of agricultural products will often fluctuate. A complete supply chain of agricultural products must be established to meet the market demand. The supply chain of agricultural products covers the production, acquisition, processing, storage, transportation and sales of agricultural products. Compared with the supply chain of industrial products, the supply chain of agricultural products is more affected by external factors such as the natural environment, policies, regulations and social environment, and there are many uncertainties and high risks. Identifying and controlling various risk factors in the supply chain of agricultural products is very important to ensure the safe and efficient operation of agricultural products. The agricultural supply chain refers to the whole process from agricultural production, agricultural product processing, storage and transportation, sales and after-sales service. In this process, various risk factors are involved, such as natural risk, market risk, policy risk, technical risk and so on. These risk factors affect different links in the agricultural supply chain, making problems in the operation process easy. For example, in agricultural production, natural disasters, climate change and other factors may lead to crop failure, thus affecting the stable operation of the agricultural supply chain. In the processing, storage and transportation of agricultural products, technical equipment failure, loss during transportation, etc., may lead to the decline of agricultural product quality, affecting the quality and efficiency of the agricultural supply chain. In the marketing link, market fluctuations, policy changes and other factors may make the price of agricultural products fluctuate, affecting the efficiency of the agricultural supply chain.

The agricultural supply chain is one of the foundations of agricultural industrialization and modernization, so improving the overall agricultural supply chain can lay the foundation for agricultural and rural economic development and even rural revitalization. However, there is more serious information asymmetry and interest disharmony among the participants of the agricultural supply chain under the market behaviour. From the external environment, problems such as imperfect credit systems and unbalanced strength of participants in the agricultural economy will further aggravate this information asymmetry and uncoordinated interests. The study of agricultural supply chain risk factors is of great significance for improving the overall competitiveness of the agricultural industry, ensuring national food security and safeguarding the interests of consumers. An in-depth study of agricultural supply chain risk assessment can help related enterprises and decision-making departments identify risks in advance and take effective measures to prevent and control them. This can reduce the supply chain's impact in natural disasters, market changes, etc., to ensure a stable supply of agricultural products. The scientific identification of agricultural supply chain risk factors can provide a basis for agricultural capital subsidies, industrial support, and fiscal and tax policies and help formulate feasible policies and measures to promote agriculture's sustainable and healthy development. It also helps agricultural enterprises to identify risk factors in their operations according to the research results, formulate practical and effective coping strategies, and improve their anti-risk ability.

2. Literature Review

Due to the agricultural supply chain's complexity and uncertainty, enterprises face various risks, such as market risk, credit risk, logistics risk, quality risk and so on. Therefore, it is very necessary to evaluate the risk of agricultural supply chain enterprises. The research on enterprise risk assessment of agricultural supply chains has been widely concerned worldwide. Agricultural supply chain enterprise risk assessment is a complex process requiring various factors and evaluation methods. In terms of supply chain risk assessment, Tran et al. (2018) made a comprehensive analysis of all aspects of supply chain risk assessment in the literature, including the definition of heterogeneity, focus, procedures, methods and indexes of supply chain risk assessment mentioned in previous studies, and prospected future studies. Aqlan & Lam (2015) proposed a comprehensive framework for supply chain risk assessment, consisting of three main components: investigation, bow analysis, and fuzzy reasoning system. The results showed that such an analytical framework could be used to evaluate supply chain risk effectively.

According to Jaffee et al. (2010), the main influencing factors of agricultural supply chain risk included unpredictable weather, unpredictability of biological processes, obvious seasonality of production and market cycle, uncertain political economy, etc. They provided a conceptual framework *for system-wide assessment and a set of detailed guidelines for agricultural internal risk, risk management and vulnerability assessment supply chains. Bloemh of et al. (2015) proposed a quantitative risk assessment method, which integrated three steps of risk identification, estimation and evaluation. The method was applied to the meat supply chain, taking into account risks in terms of animal welfare and food safety. The research showed that quantitative models could effectively assess the risks of complex agricultural supply chains. Leat & Revoredo Giha (2013) constructed a dynamic stochastic general equilibrium model to simulate the risks and uncertainties agricultural supply chains face. The model considered random factors such as productivity, demand and price fluctuations. The results showed that different types of agricultural enterprises had different risk tolerance. Banterle & Stranieri (2008) used the editable analytic hierarchy process (AHP) to assess the risks of the Italian agricultural supply chain, including production, storage, processing and distribution links. Policy and market factors were the main risk factors in this supply chain, and this approach supported the development of risk management strategies. Dong& Stranieri (2016) developed an ex-ante supply chain risk assessment model based on order of magnitude AHP (OM-AHP) to compare tangible and intangible factors affecting supply chain risk and provided an example to prove the effectiveness of the proposed risk assessment framework. Ganguly & Kumar (2019) provided a method based on a fuzzy analytic hierarchy process (FuzzyAHP) to assess supply chain risks, identifying 16 risk factors. The results showed that this method can effectively identify supply chain risks. Nakandala et al. (2017) proposed a hybrid model that includes fuzzy logic (FL) and hierarchical holographic modelling (HHM) techniques, and a case study of a fresh food supply chain company showed that this novel approach took advantage of the advantages of both techniques. Jiang et al. (2018) showed that port service process risk, operation risk, port relationship process risk and external environment-related risk were too high in the supply chain. Ghadge et al. (2017) used data triangulation to collect and analyze data through interviews, questionnaires, expert opinions, and quantitative modelling, and the findings suggested that managers should conduct robust risk assessments at the design stage to avoid product safety and security risks. Jaberidoost et al. (2015) used AHP and rating scales to conduct questionnaire surveys and expert consultations for risk analysis and used simple additive weighting methods for risk assessment to identify 86 major risks in the drug supply chain, which were divided into 11 categories. Liu et al. (2022) identified risk factors in intelligent supply chain, adopted hierarchical cluster analysis, and proposed an improved risk assessment model containing 22 risk factors. Chaudhuri et al. (2013) proposed a step-by-step approach to supply chain risk assessment in the new product development process, including group decision-making. The results showed that by using this approach, organizations could develop control plans to mitigate vendor-related risks during new product development. Vishwakarma et al. (2016) proposed a multi-criteria decision-making method based on fuzzy analytic Hierarchy Process (AHP). They identified 24 kinds of risks under five risk measures in the Indian drug supply chain. The result analysis showed that supply and supplier risk were the most important risks in the Indian drug supply chain.*

Junaid et al. (2019) proposed a comprehensive supply chain risk management method, which combined the analytic hierarchy process (AHP) and ideal solution similarity ranking technology. The research showed supply chain elasticity is the most important standard for managing supply chain risk. Tummala & Schoenherr(2011) showed that applying the supply chain risk management process (SCRMP) can effectively manage supply chain risk. Diaz-Curbelo et al. (2020) found that integrated and destructive analytical methods with multi-criteria decision-making were the most common type and tended towards Petri nets and multi-criteria decision-making methods. Supply risk was the most studied type in supply chain risk management, and identification and evaluation are the most developed processes. Sreedharan et al. (2019) found that supplier, production, demand, infrastructure, and macro risks were the sources of supply chain risk in the pharmaceutical industry. Tuncel & Alpan's (2010) findings indicate that system performance can be enhanced through risk management measures, and overall system costs can be reduced through mitigation measures. Ritchie et al. (2008) believed risk structure should be included in measuring organizational performance. Radivojevic & Gajoviæ (2014) described the main features of the supply chain and established a risk assessment model based on AHP and fuzzy AHP. The results showed that AHP and FAHP could be used to rank supply chain risk categories, determine their share in the total risk, and as a supply chain risk assessment method. It can be seen from the existing research literature that the research of supply chain risk evaluation arose in the 1990s, and the research of supply chain risk evaluation mainly focuses on three aspects: risk identification, risk assessment method and risk control strategy.

The study determined the supply chain risk dimensions and specific risk factors in the risk identification. In terms of evaluation methods, both qualitative and quantitative evaluation methods are paid equal attention, and simulation evaluation based on system dynamics appears. In terms of risk control strategy, strengthening supply chain cooperation, improving supply chain transparency and using information technology are effective countermeasures. Overall, the supply chain risk assessment research framework has initially taken shape, but the model-building and management countermeasures still need further exploration. Future research can be expanded in case verification and risk control optimization. Therefore, the critical-entropy weight-VIKOR model is proposed in this study, aiming to further optimize the index weight of agricultural supply chain risk and carry out a more scientific and objective evaluation of agricultural supply chain enterprises. The traditional subjective weighting method has the randomness of determining weights, but the entropy weighting method is too absolute and does not consider the correlation between indexes. Therefore, the critical-entropy weigh-VIKOR model is proposed in this study, aiming at further optimizing the determination of index weight of agricultural supply chain risk and carrying out a more scientific and objective evaluation for agricultural supply chain enterprises, which can effectively distinguish the risk degree of agricultural supply chain enterprises and provide decision support for agricultural supply chain enterprises to formulate differentiated risk management strategies.

3. Methodology

3.1. Model Introduction

(1) Combination Weight Determination

Firstly, it calculates weight using the CRITIC (Criteria Importance through Intercriteria Correlation) empowerment method. CRITIC method is an indicator weight determination method based on indicator correlation and is an objective weighting method proposed by Diakoulaki et al. (1995). In the comprehensive analysis of multi-index evaluation objects, this method takes into the consideration of conflict between each evaluation index and the change of index weight caused by the change of measured value. With n evaluation indexes and m and measured data, matrix $A = [a_{ij}]_{mxn}$ is established, where a_{ij} represents the value of the j^{th} index of the ITH scheme. In Toiminate the difference between different indexes, the benefit indexes are treated positively. The cost index is reverse-processed. The normalized matrix $B = [b_{ij}]_{mxn}$ is obtained. The correlation coefficient matrix $R = [r_{ij}]_{mxn}$ is calculated, where r_{ij} is the Pearson correlation coefficient between the i^{th} index and the j^{th} index, and its calculation formula is shown in Eq. (1).

$$r_{ij} = \frac{\sum_{k=1}^{n} (b_{ik} - \bar{b}_i)(b_{jk} - \bar{b}_j)}{\sqrt{\sum_{k=1}^{n} (b_{ik} - \bar{b}_i)^2} \text{ x } \sqrt{\sum_{k=1}^{n} (b_{ik} - \bar{b}_i)^2}} \tag{1}$$

In formula (1), $\bar{b}_i$ and $\bar{b}_j$ represent the mean of index i and index j in matrix B, respectively. Then, the Gini coefficient is calculated by Eq. (2).

$$\gamma_j = \frac{\sum_{i=1}^{m} \sum_{k=1}^{m} |b_{ij} - b_{kj}|}{2m\sum_{i=1}^{m} b_{ij}} \tag{2}$$

In formula (2), $\gamma_j \in [0,1]$ and j are closer to 1, indicating that the information distribution of indicator j is more unbalanced, the greater the amount of information. The closer to 0 is, the more balanced the information distribution of index j and the smaller the amount of information. Then, the information coefficient g_j is calculated. To ensure the correctness of the final result, the absolute value of the Pearson correlation coefficient was used to calculate the information coefficient. The calculation is shown in Eq. (3).

$$g_j = \sum_{j=1}^{n} (1-|r_{ij}|) \quad (3)$$

The comprehensive information amount G_j of indexes is calculated, and the weight ω_j is determined. The greater the G_j, the greater the amount of information in the j index, and the greater the corresponding weight. The calculation is shown in Eq. (4).

$$g_j = \gamma_j \cdot g_j,\ \omega_j = \frac{G_j}{\sum_{i=1}^{n} G_j} \quad (4)$$

Then, the entropy weight model is used to further calculate the weight. Zeleny (1998) systematically proposed the concept of entropy weight method for the first time and gave a specific calculation method. He uses the concept of information entropy to determine the weight of each evaluation index according to its universality and recognition. In the entropy weight model, the information entropy E_j of the horizontal j^{th} index.

$$E_j = -K \sum_{j=1}^{n} P_{ij}\, ln\,(P_{ij}) \quad (5)$$

Among them, $K = \frac{1}{\ln n'}$ *$0 \le E_j \le 1$.Then, continue to calculate the difference coefficient d_j, as shown in Eq. (6).*

$$d_j = 1 - E_j \quad (6)$$

Then, the weights of each measurement index are determined, as shown in Eq. (7).

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (7)$$

According to Eqs. (4) and (7), the weights calculated by CRITIC method and entropy weight method are combined and weighted, as shown in Eq. (8).

$$Y_j = (G_j + W_j) / 2 \quad (8)$$

(2) Risk Assessment

The VIKOR method was proposed by Opricovic & Tzeng (2004). VIKOR method is a multi-criteria decision analysis method. The multi-attribute decision scheme is sorted and selected by calculating group utility, individual regret, and compromise values the basic idea is that the optimal solution and the worst solution are determined in the set of all feasible solutions. Then, a comprehensive evaluation is carried out according to the degree of proximity between each solution and the optimal solution and the degree of distance between the worst solution; that is, the closer the optimal solution is and the more distant the worst solution is. In this process, it is often necessary to make compromises among decision attributes to obtain a feasible solution that considers maximizing group utility and minimizing individual loss. The specific steps are as follows: the matrix A= $[a_{ij}]_{m\text{x}n}$

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (9)$$

is weighted. The combined weight Y_j is obtained using the formula (8).The weighted matrix X is obtained as shown in Eq. (9).

Then, positive ideal solutions x^+_j and negative ideal solutions x^-_j for each index are determined, as shown in Eq. (10).

$$x^+_j = \{max\ x_{1j}, max\ x_{2j}, ..., max\ x_{nj}\}\ (j = 1, 2, ..., m)$$
$$x^+_j = \{min\ x_{1j}, min\ x_{2j}, ..., min\ x_{nj}\}\ (j = 1, 2, ..., n) \quad (10)$$

When the positive ideal solution is taken as a reference, the group utility value and individual regret value of each scheme are shown in Eq. (11).

$$S^+_j = \sum_{i=1}^{m} w_i (x^+_t - x_{ij}) / (x^+_t - x^-_t)$$
$$R^+_j = max\ [w_i (x_{ij} - x^-_t) / (x^+_t - x^-_t)] \quad (11)$$

When the negative ideal solution is taken as a reference, the group utility value and individual regret value of each scheme are shown in Eq. (12).

$$S^-_j = \sum_{i=1}^{m} w_i (x_{ij} - x^-_i) / (x^+_t - x^-_i)$$
$$R+_j = max\ \left(w_i (x_{ij} - x^-_i) / (x^+_i - x^-_i)\right) \quad (12)$$

Finally, the compromise value Q_i of each scheme is calculated, as shown in Eq. (13).

$$S^+ = min_i\ \{S_i\},\quad S^- = max_i\ \{S_i\}$$
$$R^+ = min_i\ \{R_i\},\quad R^- = max_i\ \{R_i\} \quad (13)$$
$$Q_i = \mu\ \frac{S_i - S^-}{S^+ - S^-} + (1 - \mu)\ \frac{R_i - R^-}{R^+ - R^-}$$

In Eq. (13), μ represents the compromise coefficient, also known as decision mechanism coefficient, and represents the proportion of group utility. Its general value is 0.5, which is also adopted in this study.

3.2. Data Source

By expanding the reading of relevant literature on enterprise risk of agricultural supply chain, this study sorted out and understood the current research status and main influencing factors of enterprise risk of agricultural supply chain, and preliminarily determined the risk assessment framework. Then, 8 experts in enterprise risk assessment of agricultural supply chain were consulted, and the indexes of influencing factors were collected through interviews and questionnaires. Then, according to the data and suggestions provided by 8 experts, combined with the results of literature research, the index system was optimized and integrated by brainstorming method. Finally, experts were invited again to comment on the optimized index system, and finally, a consensus was formed. This study finally put forward a two-level, multi-classification index system of agricultural supply chain enterprise risk, which consists of five indexes: policy environment risk, market environment risk, policy adjustment risk, consumer demand change risk and natural change risk, and 17 secondary indexes. The specific index system of enterprise risk influencing factors of the agricultural supply chain is shown as follows(Table 1).

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Primary index	Secondary index	Index number
Policy environment risk	Policy adjustment risk Risk of changes in government subsidies Trade barrier risk	X-1-1 X-1-2 X-1-3
Market environment risk	Market supply and demand changes risk Price fluctuation risk Risk of changes in consumer demand Import policy change	X-2-1 X-2-2 X-2-3 X-3-1
Policy adjustment risk	Export policy adjustment Industrial policy Change of consumption concept	X-3-2 X-3-3 X-4-1
Risk of changes in consumer demand	Improvement of consumption level Change in consumption preference Increase in extreme weather Agricultural season getting longer	X-4-2 X-4-3 X-5-1 X-5-2
Natural variation risk	Resource supply risk Climate change risk Disaster risk	X-5-3 X-5-4 X-5-5

Table 1. Index system of enterprise risk influencing factors in agricultural supply chain

After establishing the enterprise risk factor index system of agricultural supply chain, we invited 8 experts in the field of agricultural supply chain enterprise risk assessment to conduct risk assessment on 15 representative agricultural supply chain enterprises in the agricultural economic development zone of a city in Shandong Province. According to the constructed index system, each expert needs to consider the effect of various influencing factors on the risk of enterprises and use the scoring method of 1-10 points to score 15 enterprises. To make the scoring results more fair and representative, each expert must fully understand the indicator system and scoring criteria before scoring and evaluate and score according to the operation and management data provided by the enterprise. After the score, the study collects the score table submitted by the experts. Firstly, it removes one of the highest and one of the lowest scores, calculates the average score of 15 companies, and finally gets the original data set.

4. Results

4.1. CRITIC Weight

Index weights of X-1-1, X-5-1 and X-5-2 are the largest, which are 6.76%, 6.75% and 6.57% respectively (Table 2). First of all, it is mainly because there are certain policy controls in the production and circulation of agricultural products, such as the regulation of the proportion of planting area and the price guidance of the sales link. These policies will have a significant impact on the structure of agricultural production and the functioning of supply chains. When the policy is greatly adjusted, policy changes will lead to greater risks in the supply chain. It's because agricultural production and supply chain operation are cyclical and cannot immediately adapt to the new policy requirements. Secondly, the increase in extreme weather affects primary agricultural production more directly. Storms, floods, fog, drought and other extreme weather will seriously hinder the normal growth of crops, resulting in a significant reduction in production. This will not only affect farmers' planting income but also cause the processing and sales enterprises in the entire supply

Index number	Index variability	Index conflict	Amount of information	Amount of information
X-1-1	2.149	15.413	33.123	6.76%
X-1-2	1.956	15.124	29.586	6.04%
X-1-3	1.847	17.018	31.429	6.42%
X-2-1	1.562	14.261	22.278	4.55%
X-2-2	1.730	16.186	28.007	5.72%
X-2-3	1.864	16.290	30.362	6.20%
X-3-1	1.737	15.562	27.030	5.52%
X-3-2	1.740	17.132	29.817	6.09%
X-3-3	1.733	14.633	25.359	5.18%
X-4-1	1.769	14.390	25.458	5.20%
X-4-2	1.836	17.482	32.100	6.56%
X-4-3	1.936	15.736	30.459	6.22%
X-5-1	2.139	15.459	33.072	6.75%
X-5-2	2.060	15.619	32.179	6.57%
X-5-3	1.618	15.594	25.231	5.15%
X-5-4	1.846	15.572	28.743	5.87%
X-5-5	1.554	16.347	25.410	5.19%

Table 2. CRITIC weight results

chain to face a shortage of raw materials. Extreme weather can also disrupt certain infrastructure and logistics transport conditions, such as typhoons that cause road disruptions, further impeding the flow of products through the supply chain. These consequences will seriously disrupt the regular operation of the supply chain so that enterprises cannot carry out production and sales according to the scheduled plan. Finally, the longer agricultural season is related to climate change, which has already affected the planting season of traditional agriculture. The uncertain change in the timing of the bearing season also makes it difficult for supply chain enterprises to estimate the quantity of raw material purchased accurately. In general, the longer agricultural season has increased the difficulty of supply chain coordination, and it is impossible to effectively adjust the production and marketing relationship according to the traditional model.

4.2. Entropy Weight

Entropy weight of X-5-1, X-5-2 and X-1-2 is the largest, which are 8.91%, 8.08% and 7.79% respectively (Table 3). Two of the top three index weights obtained by the entropy weight method (i.e. X-5-1, X-5-2) are consistent with the CRITIC weight method. The X-1-2 weight obtained by entropy weight method ranks third, mainly because, from the perspective of supply chain management theory, changes in government subsidies will have a significant impact on the dynamic balance of agricultural supply chain. Agricultural production is highly dependent on government subsidies, which will not only affect the planting structure and output, but also produce a signal guiding effect on farmers' planting expectations, thus affecting the supply of agricultural products.

At the same time, the processing and circulation links will also adjust their procurement scale, capacity layout and production and marketing strategies according to the government's support for agricultural products. It can be said that changes in government subsidies will lead to changes in the cost-benefit structure of the upstream and downstream of the supply chain, impacting the original equilibrium state of the supply chain. This impact stems from the interaction between two major forces, policies and the market, and is amplified through the traction between various links in the supply chain. As a result, the risks associated with changes in government subsidies can be more systemic than other common risks.

Item	Information entropy value e	Information utility value d	Weight coefficient *w*
X-1-1	0.9729	0.0271	6.86%
X-1-2	0.9692	0.0308	7.79%
X-1-3	0.9783	0.0217	5.50%
X-2-1	0.9851	0.0149	3.78%
X-2-2	0.9776	0.0224	5.68%
X-2-3	0.9759	0.0241	6.10%
X-3-1	0.9817	0.0183	4.63%
X-3-2	0.9789	0.0211	5.34%
X-3-3	0.9844	0.0156	3.94%
X-4-1	0.9796	0.0204	5.16%
X-4-2	0.9754	0.0246	6.22%
X-4-3	0.9744	0.0256	6.48%
X-5-1	0.9648	0.0352	8.91%
X-5-2	0.9681	0.0319	8.08%
X-5-3	0.9789	0.0211	5.34%
X-5-4	0.9746	0.0254	6.43%
X-5-5	0.9851	0.0149	3.77%

Table 3. Entropy weight results

4.3. VIKOR Sort

According to the ranking results of Q value (Table 4), enterprise 14 is the best overall performer, and its S value of 0.2899 and R-value of 0.0539 are the smallest. This shows that Enterprise 14 is close to the optimal level in combating policy environment risk, market environment risk, policy adjustment risk, consumer demand change risk, natural change risk and so on, and can be used as a model enterprise. The main reason may be that Enterprise 14 has established a sound risk identification mechanism and can find various risk points in the supply chain promptly. An organizational structure matching supply chain risk management and control has been established to ensure that risk decisions and measures are effectively implemented. At the same time, it has many supply chain risk management talents, adopts information technology to improve the *transparency and response speed of the supply chain and attaches importance to strategic cooperation with supply chain partners. Thus, this reduces the risk of cooperation and gives it the supply chain's industry-leading overall control and coordination ability. In particular, the R-value of enterprise 8 is second only to that of enterprise 14, which shows that its strong agricultural supply chain management ability is very strong, and these two enterprises also have strong overall supply chain coordination ability. Enterprise 13, enterprise 7 and enterprise 15 are rated as the top three, and their S-value and R-value are large, especially the S-value of enterprise 7 reaches the highest 1, indicating that there is still a large gap between its supply chain management index and the optimal level. Based on the critical-entropy weight-VIKOR model, this study evaluates different agricultural supply chain enterprises in the face of agricultural supply chain risks and can more accurately identify benchmarking enterprises with outstanding supply chain management ability in the sample enterprises and inefficient enterprises with shortcomings that need to be focused on improving. This study objectively divides the levels of supply chain management between enterprises through quantitative data and provides a reference for the future development path of agricultural supply chain enterprises.*

Agricultural supply chain enterprise number	The sum of distance ratio S of the optimal scheme	The maximum value of the optimal scheme distance ratio R	Profit ratio Q value	Scheme (Q value) ranking
1	0.5567	0.0584	0.9065	11
2	0.3869	0.0562	0.4492	3
3	0.4803	0.0588	0.8149	9
4	0.4236	0.0588	0.7211	7
5	0.3888	0.0588	0.6635	6
6	0.4739	0.0556	0.5465	4
7	0.5922	0.0588	1.0000	15
8	0.3933	0.0526	0.1710	2
9	0.4703	0.0587	0.7873	8
10	0.5804	0.0588	0.9805	13
11	0.5323	0.0588	0.9010	10
12	0.4143	0.0577	0.6148	5
13	0.5912	0.0588	0.9984	14
14	0.2899	0.0539	0.1070	1
15	0.5416	0.0588	0.9163	12

Table 4. VIKOR analysis results

5. Conclusions

China is in a critical period of agricultural supply-side structural reform. Optimizing the agricultural supply chain, constructing a systematic agricultural supply chain risk assessment framework and model, and implementing quantitative risk monitoring have become the inevitable needs of current research. This study proposes an enterprise risk evaluation index system for the agricultural supply *chain, consisting of five primary and 17 secondary indexes. The CRITIC and entropy weight methods are adopted to determine the enterprise risk index weight of the agricultural supply chain. The VIKOR method evaluates risk on 15 agricultural supply chain enterprises in an agricultural economic development zone. This study draws three conclusions. (1) Based on the existing literature, the enterprise risk evaluation index system of the agricultural supply chain constructed in this study is relatively scientific and reasonable. (2) The CRITIC weights of X-1-1, X-5-1, and X-5-2 are the highest. The entropy weight of X-5-1, X-5-2 and X-1-2 is the largest. (3) The critical-entropy weight-VIKOR model can effectively distinguish the degree of risk of different agricultural supply chain enterprises. It is suggested that further research should be carried out on the construction of dynamic risk assessment models, real-time monitoring of agricultural supply chain risk, integration of multi-source heterogeneous data to improve model prediction, and development of risk management systems to support decision-making.*

Declarations of Interest

None

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