Research on the Hierarchy of Agricultural Product Supply Chain Based on Fuzzy Analytic Hierarchy Process

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Abstract. The stability and elasticity of the agricultural product supply chain are of great significance for agricultural development. Based on the introduction of the connotation of agricultural product supply chain, combined with the current operation mode, development status, demand changes at each node of the supply chain, and product form changes of China's agricultural product supply chain, the evaluation index system of agricultural product supply chain is selected on the basis of existing research. Through the fuzzy comprehensive evaluation method based on analytic hierarchy process to perform certain operations, and combined with practical cases for application analysis, verifying the feasibility of the evaluation model also has certain practical significance. Enterprises can thus understand the weak parts of supply chain elasticity and make improvements.

Keywords: agricultural product supply chain; AHP fuzzy comprehensive evaluation method; WSR method; Supply chain elasticity.

1. Introduction

In recent years, high attention has been paid to the quality and logistics of agricultural products. In order to achieve rural revitalization and accelerate the development of rural agriculture, the country has successively introduced a series of policies. However, reports on quality issues of agricultural products continue to emerge in an endless stream, indicating that there are still shortcomings in the management of agricultural product supply chains. Therefore, it is of great practical significance to study the elasticity of agricultural product supply chain.

Currently, research at home and abroad focuses more on case studies and the interpretation of relevant phenomena. For example, Yang Yefei [1] proposed that the key factor for maintaining stability in the agricultural product supply chain under the complex economic situation was the degree of coordination and cooperation among various enterprises in the chain, and analyzed corresponding evaluation indicators and quantitative models. The study of supply chain elasticity reveals four important issues of supply chain connotation, operation, shaping, and optimization. For example, the concept of "elastic triangle" constructs a supply chain elasticity measurement determination model, and provides specific elasticity measurement indicators from a qualitative perspective [2]. Lu Shan [3] repeatedly played a limited number of games based on reputation institutions under complete information conditions without restriction. Yan Ximu and Qin Na [4] put forward a number of forward-looking suggestions for the development of e-commerce supply chains in the agricultural product industry through example analysis, combining micro and macro related data.

In the research and evaluation of agricultural product supply chain elasticity, a single indicator will produce significant errors, and the effect of summarizing multiple indicators will be closer to the actual situation. Therefore, a multiple indicator evaluation method is adopted. There are many comprehensive evaluation methods at home and abroad, but they can only be roughly divided into two categories: one is the subjective evaluation method by scientists based on their own experiences and knowledge, also known as the subjective empowerment evaluation method; The other type is the objective evaluation method, which establishes corresponding functions based on the correlation between data indicators to obtain their subordinate relationships. The two methods use different scenarios, each with advantages and disadvantages. The evaluation of supply chain elasticity includes both qualitative and quantitative indicators. Fuzzy Analytic Hierarchy Process can effectively combine the two, combining expert evaluation to determine the index weight, and can achieve good results.

Through literature review, it was found that the relevant research on agricultural product supply chain mainly focuses on supply chain operation mode, supply chain production efficiency, and optimization methods, with less research on the evaluation of supply chain elasticity. Therefore, on the basis of sorting out the content and considering the characteristics of market agricultural products, this article intends to adopt a fuzzy comprehensive evaluation method based on Analytic Hierarchy Process. The concept of "membership degree" in fuzzy mathematics is added to the original Analytic Hierarchy Process, and the membership function is used to process the fuzzy indicators, thereby reducing the impact of subjective factors on the elasticity evaluation of the agricultural product supply chain.

2. Building an indicator system based on the WSR method

To obtain realistic conclusions from the research on agricultural product supply chain elasticity, it is necessary to establish a scientific and reasonable evaluation index system. Currently, there are many types of evaluation index systems for supply chain elasticity research. Based on supply chain research, this article, in accordance with the principles of comprehensive, representative, and feasible index system construction, adds a new WSR (Physical Rationality Human Rationality) supply chain evaluation index, and constructs a fresh agricultural product supply chain elasticity index system from three aspects: physical, physical, and human.

Physical physics is a method used to explore the objective material world, laws, and rules. It mainly discusses the issues in "What is it?" and reveals its internal mechanism through systematic functional analysis. The construction of supply chain elasticity indicators for fresh agricultural products is not only a comprehensive and precise decomposition of the supply chain system from the physical dimension, but also ensures the completeness of the indicator system. In the physical dimension, the main considerations are the completeness of infrastructure, user friendliness, and network complexity.

In WSR methodology, governance refers to logical analysis, as well as the methods and strategies that should be followed during the operation of things, so as to be able to reasonably analyze and effectively solve problems. It focuses on the mechanism and organizational analysis that affect the system. The rational dimension mainly focuses on the research of flexible management of agricultural product supply chain. Resilience management includes risk prediction, identification and management, timeliness of information, and policy feedback and resilience.

In the WSR methodology, the human factor and human factor dimension focuses on the changes in the relationships between people in the system. It is a supply chain organizational system established based on division of labor and collaboration. The internal factors of the system are mutually constrained and interconnected, guiding people to achieve system goals. The human factor dimension mainly focuses on the analysis of personnel related to the agricultural product supply chain, including the number of suppliers, supply chain supply quality, and trust crisis.

After the above analysis, the evaluation index system for the supply chain elasticity of fresh agricultural products is obtained as shown in Table 1.

Table 1. Supply Chain Elasticity Index System for Fresh Agricultural Products

Elasticity Index System of Fresh Agricultural Products Supply Chain (A)	Attribute layer	Primary indicator	Secondary indicators
	Physical dimension	Hardware facilities (B1)	Infrastructure Integrity (C11)
			Usage friendliness (C12)
			Network Complexity (C13)

	Rational dimension	Resilient Management (B2)	Risk prediction identification management (C14)
			Timeliness of information (C15)
			Policy feedback response ability (C16)
	Humanistic dimension	Relevant personnel (B3)	Number of suppliers (C17)
			Supplier Supply Quality (C18)
			Trust Crisis (C19)

3. Method for determining evaluation indicators of agricultural product supply chain elasticity based on WSR method

Analytic Hierarchy Process (AHP) is a method of decomposing a complex decision-making process into several independent steps, including overall objectives, principles, methods, etc., in order to better develop qualitative and quantitative analysis methods, and more effectively achieve decision-making objectives.

3.1 Determination of evaluation index weight based on analytic hierarchy process

The judgment matrix A is constructed, and the evaluator can obtain the constructed matrix A by comparing the relative importance of the evaluation index i and the index j.

① Geometric Average $\overline{\omega}=\sqrt[n]{\prod_{j=1}^{n} a_{ij}}$,i=1,2,3,..., n

② Get $\overline{\omega}=(\overline{\omega_1}, \overline{\omega_2}\ldots\overline{\omega_n})^T$, Normalization $\omega_i=\frac{\overline{\omega_i}}{\sum_{i=1}^{n}\overline{\omega_i}}$ at this time, $\overline{\omega}=(\overline{\omega_1}, \overline{\omega_2}\ldots\overline{\omega_n})^T$ is a relative weight.

③ Finding the maximum value of a matrix λ_{max} $\lambda_{max}=\sum_{i=1}^{n}\frac{(A\overline{\omega})_i}{n\overline{\omega_i}}$

④ Consistency inspection CI= $\frac{\lambda_{max}-n}{n-1}=\frac{\sum_{i\neq\lambda_{max}}\lambda_i}{n-1}$

In the calculation formula λ_{max} is the maximum characteristic value; The order of the matrix is n.

⑤CR= $\frac{CI}{RI}$"RI is an average random consistency index, and when CR>0.1, the judgment matrix should be appropriately modified.". On the contrary, when CR ≤ 0.1, it indicates that the consistency of the judgment matrix is acceptable.

3.2 Establishment of evaluation model based on fuzzy comprehensive evaluation method

① A collection of evaluation values made by the evaluator based on the status of the evaluation object is called a comment set. Mark as V= $\{V_1, V_2, V_3, V_4, V_5\}$= {很好，较好，一般，差，很差}

② Invite experts in the industry who have in-depth research and insights into relevant fields to score, and the determination of the degree of membership is based on the proportion of the number of experts scoring indicators to the total number of people.

③ The index weights obtained by AHP are combined with the fuzzy comprehensive analysis method to obtain a factor evaluation matrix.

$$\omega_1\times R_1=(a_{11},a_{12},\ldots a_{1j})\begin{bmatrix} r_{11} & \cdots & r_{1j} \\ \vdots & \ddots & \vdots \\ r_{ij} & \cdots & r_{ij} \end{bmatrix}=B_1$$

B_1 is a single factor evaluation variable, which can be obtained similarly B_2， B_3， B_4， B_5。

④ According to the above calculation results, the total evaluation matrix can be obtained, $R=\begin{pmatrix} B_1 \\ \cdot \\ \cdot \\ \cdot \\ B_i \end{pmatrix}$ to obtain a fuzzy comprehensive evaluation of B=A × R。

4. Case Study: Taking Agricultural and Industrial Supermarkets as an Example

4.1 Weighting based on AHP indicators

Given the elasticity index system in Table 1, according to the method used in this article, perform data processing operations according to the steps in 3.1 above. According to the analytic hierarchy process calculation results of indicator system A, the relative weight $\overline{\omega}$=（0.0663，0.0428，0.2635），λ_{max}=3.07. According to the RI table, the corresponding RI value is 0.52, so $CR=\frac{CI}{RI}=0.07<0.1$, so it passed the consistency test. Similarly, other judgment matrices have been calculated through the above steps, and the results obtained have passed the consistency test. The calculation of weight indicators at all levels is shown in Table 2.

Table 2 Weights of Each Index

index	Weight value
B1 Hardware facilities	0.0663
B2 Elastic Management	0.0428
B3 Relevant personnel	0.2635
C11 Basic equipment completeness	0.2492
C12 User friendliness	0.5736
C13 Network complexity	0.5
C14 Risk Prediction Identification Management	0.4
C15 Timeliness of information	0.0417
C16 Policy Feedback Response Capacity	0.4379
C17 Number of suppliers	0.1533
C18 Supplier Supply Quality	0.2876
C19 Trust Crisis	0.1428

4.2 Based on the AHP fuzzy comprehensive evaluation described in this article

In order to meet the requirements of the AHP fuzzy comprehensive evaluation method, we consulted local enterprise management personnel and university experts related to the supply chain of fresh agricultural products, and invited experts from various industries to give subjective scores on various indicators. For details, see Table 3.

Table 3 Scoring Results of Each Expert

index		Evaluation results				
Primary indicator	Secondary indicators	Very good	preferably	commonly	difference	Very poor

B1 Hardware facilities	C11 Basic equipment completeness C12 User friendliness C13Networkcomplexity	8 7 9	8 6 2	6 7 4	4 5 3	2 4 3
B2 Elastic Manageme nt	C14 Risk Prediction Identification Management C15 Timeliness of information C16 Policy Feedback Response Capacity	10 8 7	7 7 8	5 4 5	4 3 6	2 1 2
B3 Relevant personnel	C17 Number of suppliers C18 Supplier Supply Quality C19 Trust Crisis	9 8 8	8 9 8	5 7 6	5 1 5	3 2 4

The proportion of the number of people who score each indicator at different levels to the total number of people is the degree of membership of each result. Follow the steps described in 3.2 and use SPSSPRO software to calculate. The relevant results are summarized as follows:

Hardware facilities: B1= $\omega_1 \times R_1$=(0.252, 0.278, 0.139), the same can be obtained

Elastic management: B2=(0.352, 0.247, 0.153);

Relevant personnel: B3=(0.318, 0.249, 0.128);

After evaluation, we have scored the above fuzzy vectors. Please refer to Table 4 for details.

Table 4 Fuzzy Vector Assignment

Evaluation level	V1	V2	V3	V4	V5
natural endowments	5	4	3	2	1
Evaluation results	very good	preferably	commonly	difference	Very poor

The overall scoring calculation results for the degree of information sharing in the agricultural product supply chain from the omnichannel perspective of agricultural industrial and commercial supermarkets are as follows:

$D=V\ B^T$=3.512； Therefore, the overall score D is 3.512, which is between good and average. Similarly, the score for hardware facilities is 3.413; The score of flexible management is 3.627; The relevant personnel scored 3.340.

4.3 Analysis of evaluation results

According to the fuzzy analytic hierarchy process evaluation, the total score of agricultural industrial and commercial supermarkets in terms of the degree of information sharing in the agricultural product supply chain is 3.512, which is at a higher level compared to the score in Table 4. Among them, B2 has the highest score for flexible management, indicating that the supermarket has a high quality of flexible management, thanks to its continuously improving management model and good management methods being well disseminated among partners. It can be seen that B3 has the lowest score for relevant personnel, indicating that the training for relevant personnel in the supply chain is still lacking in depth and breadth, and enterprises need to further expand the scope of skill training for relevant personnel.

5. Conclusion and outlook

Nowadays, with the continuous development of information technology, there has been a deeper connection with the supply chain. Especially when the supply chain enters the omnichannel era, information sharing plays a crucial role in the cooperation and competition of the supply chain. Based on the above evaluation results of various aspects of agricultural product supply chain information from an omnichannel perspective, the following suggestions are proposed: 1. Strengthen the exploration of the diversity and depth of supply chain flexibility management models. A flexible, resilient, and valuable supply chain management model is a key factor for each node enterprise to achieve production planning, ensure normal operation, and accurately predict market demand. 2. Strengthen the depth and breadth of supply chain information sharing. This is reflected in broadening information channels and creating an information sharing platform. Strengthen the connection between online and offline channels through platforms such as WeChat applet and Meituan APP to improve efficiency and convenience. 3. Enterprises should reasonably establish the training cycle and training content for employees. Regular, systematic, and comprehensive training can enable advanced supply chain information systems from an omnichannel perspective to display their higher value.

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