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RESEARCH ON THE CONSTRUCTION OF MATHEMATICAL MODEL OF AGRICULTURAL SUPPLY CHAIN INFORMATION SYSTEM EVALUATION UNDER BLOCKCHAIN TECHNOLOGY

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Abstract. Traditional agricultural products supply chain information systems face several problems, such as information asymmetry, tracing difficulty, and insufficient data security, which can be efficiently solved using blockchain technology due to its decentralized, non-tampered, and highly transparent characteristics. Accordingly, the application of blockchain technology in the agricultural products supply chain information system was comprehensively evaluated in this study. A comprehensive evaluation index system for the agricultural products supply chain information system was established based on blockchain technology, a mathematical model of AHP–CRITIC–TOPSIS was constructed to comprehensively evaluate supply chain information system, and an empirical study was carried out on 18 agricultural products enterprises in China. Results show that blockchain technology can significantly improve the performance of agricultural products supply chain information systems and enhance the efficiency and transparency of supply chains, and the AHP–CRITIC–TOPSIS mathematical model can be used to assess the collaboration efficiency among enterprises in this system. This study offers great reference value for promoting the digital transformation and intelligent upgrading of agricultural products supply chains, thus helping the government and supervision departments in actively supporting the application of blockchain technology and promoting a healthy development of agricultural products supply chains.

Keywords: Blockchain technology, agricultural products supply chain, information system, comprehensive evaluation, AHP–CRITIC–TOPSIS mathematical model.

AMS Subject Classification: Primary: 90B50; Secondary: 90C29, 62P20.

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1 Introduction

The efficient operation of the agricultural products supply chain, which serves as an important link between farms and households, is directly related to the quality and safety of food, the income level of farmers, and the health rights and interests of consumers. However, the traditional agricultural products supply chain faces a variety of challenges, such as information asymmetry, data non-transparency, the proliferation of counterfeit and shoddy products, and high logistics costs. These problems not only increase the fragility of the supply chain but also limit sustainable agricultural development. With the rapid development of information technology, blockchain technology provides a novel solution to these problems by virtue of its decentralized, data non-tampering, and timestamp characteristics. Blockchain technology can record the information on every link of the agricultural products supply chain from production, processing, and transportation to sales in an unchangeable distributed ledger, thereby realizing the traceability of the whole chain. This characteristic also enhances the transparency of the supply chain, reduces the risks induced by information asymmetry, cracks down on counterfeit and shoddy products, and improves the quality and safety of agricultural products. Driven by national policies, the agricultural application of blockchain technology has developed rapidly in China. The Chinese government proposed strengthening cold chain facilities, standardizing the construction of agricultural products and food, and establishing a traceability mechanism for the quality and safety of important products based on the supply chain. This policy orientation provides powerful support for the application of blockchain technology in the agricultural products supply chain. Blockchain can also be deeply integrated into agricultural big data collection systems and Internet of Things (IoT) to further improve the intelligence and refinement levels of the agricultural products supply chain. The production, processing, transportation, and other data of agricultural products are collected in real time through IoT equipment, and the precise management of agricultural products can be realized throughout their whole lifecycle by combining blockchain technology with data storage and tracking, thus further improving the efficiency and safety of the supply chain.

As an innovative information solution, the agricultural products supply chain information system offers a very important application prospect. Blockchain technology provides a very high security guarantee for this system due to its decentralized and tamper-proof data. Unlike traditional centralized databases, blockchain-based information systems can effectively prevent data from being maliciously tampered with or deleted, thus ensuring the authenticity and integrity of information. This characteristic is crucial to the agricultural products supply chain due to its direct association with the quality and safety of food and the trust of consumers. Blockchain technology can also realize the traceability of agricultural product supply chain information, thus enabling consumers to trace these agricultural products back to their production sources, processing, and transportation paths, which would enhance their trust in these products. This feature also helps regulatory authorities in supervising and tracing the agricultural products supply chain and improving their response ability to food safety incidents. In sum, comprehensively investigating the agricultural products supply chain information management system under the background of blockchain technology can lead to an efficient settlement and automatic management of agricultural product transactions, reduce transaction costs, improve supply chain operation efficiency, establish a trust mechanism, enhance the trust of consumers and supply chain partners, and promote the sustainable development of the agricultural industry.Based on the characteristics of blockchain technology and the requirements of the agricultural product supply chain information system, a more comprehensive and detailed evaluation index system can be established by using the AHP-CRITIC-TOPSIS method. In addition to the traditional evaluation indicators of the supply chain information system, technical and management indicators related to blockchain can also be incorporated, such as the stability of the blockchain network, the participation of nodes, and the degree of data sharing, so as to more comprehensively reflect the operation status and performance of the agricultural product supply chain information system supported by blockchain technology.

2 Literature Review

Dutta et al. (2020) showed that blockchain has great potential in changing the function of the supply chain starting from the supply chain source and business process reengineering to security enhancement. Saberi et al. (2019) conducted a rigorous study on blockchain technology and smart contracts and their potential applications in supply chain management. Min (2019) found that blockchain, as a peer-to-peer information technology network, uses distributed ledgers to record digital asset transactions, thereby reducing risks related to intermediary intervention. Cole et al. (2019) showed that blockchain can improve sustainable supply chain management, promote inventory management and replenishment, and reduce the demand for intermediaries and the cost of supply chain transactions. Park et al. (2021) utilized the distributed ledger technology and found that the blockchain platform provides a digital system and database for recording transactions in the supply chain. Such decentralized transaction database contributes transparency, reliability, traceability, and efficiency to supply chain management. Wang et al. (2019a) found that the value of blockchain technology to supply chain management lies in four aspects, namely, extended visibility and traceability, digitalization and disintermediation of the supply chain, improved data security, and smart contracts. Wang et al. (2019b) conducted in-depth interviews with 14 supply chain experts to understand how senior managers diagnose the obvious symptoms of a blockchain. Shen et al. (2022) found that blockchain technology is of great value in improving the efficiency of supply chain management. Zhu & Kouhizadeh (2019) found that blockchain technology may help solve information challenges and provide traceability, transparency, security, accuracy, and intelligent execution, which are helpful for product deletion and rational decision making. Kim & Shin (2019) recruited 306 supply chain experts from different industries as study objects and found that the technical characteristics of a blockchain have a significantly positive impact on partnership growth and a marginal effect on partnership efficiency. Zhu et al. (2022) organized the process of formal acceptance of blockchain technology and predicted the results of a business model supported by blockchain. Kamble et al. (2019) argued that blockchain technology is expected to bring a revolutionary paradigm shift to the transaction mode being adopted in supply chains and found that this technology enhances visibility and transparency by eliminating trust-related problems in the supply chain. Kamilaris et al. (2019) described blockchain as a very promising technology in realizing a transparent food supply chain, with many ongoing initiatives on various food and food-related issues. Kouhizadeh et al. (2021) outlined the obstacles in managing sustainable supply chains based on blockchain technology and highlighted the importance of further adopting this technology in the sustainable supply chain environment in theory and practice. Wu et al. (2023) studied the adoption of blockchain technology in the fresh products supply chain and provided valuable insights for the adoption of this technology. Yousefi et al. (2022) proposed an analytical method for determining the promoters of blockchain technology and analyzed its impact on supply chain performance. Rejeb et al. (2021) showed that blockchain technology can influence the cooperation among trading partners in the modern supply chain by simplifying the information sharing process, supporting decision-making and reward models, and strengthening communications with supply chain partners. Riera et al. (2024) believed that the establishment of community tourism information system can promote the social and economic development of coastal communities. Sánchez et al. (2023) described different types of techniques and methods for designing and implementing telemedicine consulting network systems.

The above studies highlight how blockchain technology can improve the transparency and efficiency of a supply chain, achieve multi-party data sharing, ensure information transparency, and realize the real-time updating and traceability of data in all links of the supply chain. Through this technology, consumers can learn detailed information about products and consequently build their trust in these products. Blockchain technology can also reduce the time and cost in supply chain transactions and improve the circulation efficiency of agricultural products. The technical, economic, and social feasibility of using blockchain technology in agricultural products supply chain information systems can be assessed by comprehensively evaluating these systems based on blockchain technology. The application of blockchain technology in these systems can also be optimized, and its application advantages and limitations can be further revealed to improve its practical application, underscore its successful application cases and potential value, and promote the digital transformation and intelligent upgrading of the agricultural industry.

3 Model Profile and Index System

3.1 Model Profile

The agricultural products supply chain information system was evaluated using the AHP–CRITIC– TOPSIS mathematical model. The weight of each index was calculated beforehand via AHP–CRITIC combination weighting.

(1) Analytic hierarchy process (AHP)

Saaty (1977) proposed the AHP method. A judgment matrix was initially established. Specifically, every two factors were compared according to the established hierarchical structure of risks, the quantitative scale between these factors was marked through the nine-point scaling method based on the importance of each index, and the judgment matrix was eventually obtained.

The product of elements a_{ij} in the judgment matrix was calculated by row to obtain a new vector M_i as shown in Formula (1).

$$M_i = \prod_{j=1}^{n} a_{ij} \quad (i, j = 1, 2, 3, \ldots, n). \tag{1}$$

The n-th power of each element in the new vector M_i is then taken to obtain the vector r_i as expressed in Formula (2).

$$r_i = \sqrt[n]{M_i}, \tag{2}$$

r_i was then normalized to obtain the weight vector W_i, the relative importance among various factors is reflected by constructing a judgment matrix. $\lambda_{\max}$ was the maximum characteristic root of this matrix, the consistency index T, and the consistency ratio Q, which were calculated using Formulas (3) to (6), respectively. Whether the matrix passes the consistency test was judged through the consistency ratio.

$$W_i = \frac{r_i}{\sum_{i=1}^{n} r_i}, \tag{3}$$

$$\lambda_{\max} \approx \frac{1}{n} \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} (a_{ij} W_j)}{W_i}, \tag{4}$$

$$T = \frac{\lambda_{\max} - n}{n - 1}, \tag{5}$$

$$Q = \frac{T}{K}. \tag{6}$$

(2) CRITIC method

Alinezhad et al. (2019) proposed objective weights calculating method using CRITIC. Assuming that there are m schemes and each scheme contains n indexes, the evaluation matrix X can be established, and the value of the element evaluation scheme in the matrix under the corresponding index was calculated using Formula (7).

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{7}$$

Some negative indexes may exist during the determination of risk evaluation indexes. For convenience of calculation, the indexes should be subjected to simultaneous forward/reverse conversion processing when necessary using the reduction formula in Formula (8):

$$x'_{ij} = \frac{1}{\lambda + \max|X_i| + x_{ij}}, \tag{8}$$

where x_{ij} denotes the index value, x'_{ij} denotes the index value going through simultaneous forward/reverse conversion processing, $\max|X_i|$ is the maximum value of the i-th index, and λ represents the coordination coefficient that is generally taken as 0.1. Through the above processing, the evaluation matrix X' after forward conversion processing can be acquired. Based on the standard matrix X'', the correlation coefficient ρ_{ij} between the standard deviation σ_i of each index and this index can be solved using Formulas (9) and (10).

$$\sigma_i = \sqrt{\frac{1}{m}\sum_{j=1}^{m}(x_j^n - \overline{x}_i^n)^2}, i = 1, 2, \dots, n, \tag{9}$$

$$\rho_{ij} = \operatorname{cov}(X_i^n, X_j^n)/(\sigma_i \sigma_j), i = 1, 2, \dots, n, \tag{10}$$

where x_i'' indicates the mean value of the i-th index, $\operatorname{cov}(X_i^n, X_j^n)$ is the covariance between the i-th index and j-th index, and G_i denotes the amount of information contained in each index as expressed by Formula (11).

$$G_i = \sigma_i \sum_{j=1}^{n}(1 - \rho_{ij}), i = 1, 2, \dots, n, \tag{11}$$

where a greater value of G_i reflects the higher relative importance of the i-th index and the greater amount of information contained. Based on this value, the objective weight β_i of the i-th index was calculated using Formula (12).

$$\beta_i = \frac{G_i}{\sum_{j=1}^{n} G_j}. \tag{12}$$

The subjective weight vector α and objective weight vector β were acquired using AHP and CRITIC, respectively. The comprehensive weight, which consists of the two weights, was acquired by assigning 50% to each weight according to Formula (13).

$$w_i = 0.5\alpha_i + 0.5\beta_i. \tag{13}$$

(3) TOPSIS method

Behzadian et al. (2012) proposed the TOPSIS method, which initially sets m objectives (a finite number of objectives) and n attributes. x_{ij} denotes the evaluation value given by experts to the j-th attribute of the i-th objective, and the initial judgment matrix V was computed as

$$V = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{14}$$

Given that the dimension may vary across indexes, the judgment matrix V' was obtained by normalizing the initial judgment matrix V, further deriving Formula (15).

$$V' = \begin{bmatrix} x'_{11} & x'_{12} & \cdots & x'_{1n} \\ x'_{21} & x'_{22} & \cdots & x'_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x'_{i1} & \cdots & x'_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ x'_{m1} & x'_{m2} & \cdots & x'_{mn} \end{bmatrix} \tag{15}$$

where

$$x'_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{n} x_{ij}^2}}, i = 1, 2, \ldots m; j = 1, 2, \ldots n. \tag{16}$$

A weighted judgment matrix Z (Formula (19)) was then established according to the combination weight obtained through the improved AHP and CRITIC models.

$$Z = V'B = \begin{bmatrix} x'_{11} & x'_{12} & \cdots & x'_{1n} \\ x'_{21} & x'_{22} & \cdots & x'_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x'_{i1} & \cdots & x'_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ x'_{m1} & x'_{m2} & \cdots & x'_{mn} \end{bmatrix} \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ w_{i1} & \cdots & w_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ w_{m1} & w_{m2} & \cdots & w_{mn} \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f_{i1} & \cdots & f_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{bmatrix} \tag{17}$$

According to the weighted judgment matrix, the positive ideal solution f_j^* and negative ideal solution f'_j of the evaluation object were computed as

$$\begin{aligned} f_j^* &= \begin{cases} \max(f_{ij}), j \in J^* \\ \min(f_{ij}), j \in J' \end{cases}, j = 1, 2, \ldots, n \\ f'_j &= \begin{cases} \min(f_{ij}), j \in J^* \\ \max(f_{ij}), j \in J' \end{cases}, j = 1, 2, \ldots, n \end{aligned} \tag{18}$$

where J' is a cost-type index, and J^* is a benefit-type index. The Euclidean distance between each target value and the ideal value was solved as

$$\begin{aligned} S_i^* &= \sqrt{\sum_{j=1}^{m} (f_{ij} - f_j^*)^2}, j = 1, 2, \ldots, n \\ S'_i &= \sqrt{\sum_{j=1}^{m} (f_{ij} - f'_j)^2}, j = 1, 2, \ldots, n \end{aligned} \tag{19}$$

The relative closeness C_i^* of each objective was then calculated as

$$C_i^* = \frac{S'_i}{S_i^* + S'_i}, i = 1, 2, \ldots, m. \tag{20}$$

The agricultural products supply chain information systems under blockchain technology were sorted according to the obtained relative closeness C_i^*.

3.2 Index System

Based on a large number of documents about information management systems, the author visited Zhejiang, Jiangsu, Shandong, and other provinces with agricultural products supply chain management platforms and communicated with a large number of agricultural products supply chain management platform managers. A comprehensive evaluation index system for agricultural products supply chain information systems based on blockchain technology was eventually established as shown in Table 1.

Table 1: Comprehensive evaluation index system for agricultural products supply chain information systems

First-level index	Second-level index	Second-level index No.	Data source
System performance	System response time	A1	System log
	System stability	A2	Maintenance record
	System expandability	A3	Upgrade record
	System concurrent processing capability	A4	Pressure test result
Data management	Data accuracy	B1	User feedback
	Data integrity	B2	Data backup and recovery test
	Data timeliness	B3	Real-time evaluation
	Data visualization degree	B4	Statement and chart generation capability
Information security	System security protection	C1	Intrusion detection system log
	Data encryption and decryption	C2	Key management
	User authority management	C3	Audit log
User satisfaction	System ease of use	D1	Operation training feedback
	User interface friendliness	D2	UI/UX design evaluation
	Customer service and support	D3	Problem solving rate
Business process support	Business process coverage	E1	Business process tackling and mapping
	Business process optimization capability	E2	Automation degree
	Compatibility with other system s	E3	Integration scheme
	Data exchange and sharing capability	E4	Sharing platform

4 Research Results

4.1 AHP Results

Table 2: AHP Test Results

Matrix	Maximum characteristic root	CI	RI	CR	Consistency test result
A	4.25	0.08	0.89	0.09	Pass
B	4.19	0.06	0.89	0.07	Pass
C	3.05	0.03	0.52	0.05	Pass
D	3.00	0.00	0.52	0.00	Pass
E	4.12	0.04	0.89	0.05	Pass

Table 2 shows that all the judgment matrices established in this study pass the consistency test and that the calculated weights are consistent. The AHP weights of all second-level indexes are then solved.

Table 3: AHP Weight Results

Second-level index No.	First-level index weight	Second-level index weight	AHP weight
A1	14.028%	25.000%	3.51%
A2		25.000%	3.51%
A3		16.667%	2.34%
A4		33.333%	4.68%
B1	21.806%	28.175%	6.14%
B2		17.659%	3.85%
B3		24.603%	5.36%
B4		29.563%	6.45%
C1	16.528%	41.111%	6.79%
C2		26.111%	4.32%
C3		32.778%	5.42%
D1	22.778%	50.000%	11.39%
D2		25.000%	5.69%
D3		25.000%	5.69%
E1	24.861%	29.286%	7.28%
E2		20.714%	5.15%
E3		29.286%	7.28%
E4		20.714%	5.15%

4.2 CRITIC Results

Table 4: CRITIC Weight Results

Second-level index No.	Index variability	Index conflict	Information amount	CRITIC weight
A1	18.160	16.829	305.613	5.76%
A2	16.321	17.884	291.876	5.50%
A3	14.543	16.789	244.156	4.60%
A4	15.392	17.184	264.508	4.98%
B1	18.228	16.864	307.397	5.79%
B2	16.688	17.057	284.640	5.36%
B3	19.701	16.881	332.558	6.26%
B4	18.031	17.606	317.452	5.98%
C1	18.060	17.137	309.504	5.83%
C2	17.642	17.167	302.845	5.70%
C3	17.412	16.113	280.553	5.28%
D1	16.427	16.097	264.426	4.98%
D2	15.874	17.733	281.491	5.30%
D3	19.165	17.402	333.496	6.28%
E1	14.294	18.127	259.111	4.88%
E2	17.248	17.703	305.341	5.75%
E3	18.547	18.434	341.894	6.44%
E4	18.138	15.564	282.309	5.32%

4.3 Combination Weight Results

Three-level index evaluation system was then constructed by combining AHP, CRITIC, and TOPSIS based on the relevant results. A total of 14 experts, scholars, or enterprise managers in the field of agricultural products supply chains were invited for scoring due to their rich practical experience and professional knowledge. The obtained scoring data were then analyzed for the follow-up weight calculation and comprehensive evaluation. The weight of each index was determined using AHP–CRITIC, and the weight value of each third-level index was solved as shown in Table 5.

Table 5: Combination Weight Results

First-level index	Second-level index No.	Combination weight
System performance	A1	4.63%
	A2	4.50%
	A3	3.47%
	A4	4.83%
Data management	B1	5.97%
	B2	4.61%
	B3	5.81%
	B4	6.21%
Information security	C1	6.31%
	C2	5.01%
	C3	5.35%
User satisfaction	D1	8.18%
	D2	5.50%
	D3	5.99%
Business process support	E1	6.08%
	E2	5.45%
	E3	6.86%
	E4	5.23%

4.4 TOPSIS Results

TOPSIS was applied for the ranking based on the distance between the evaluation object and positive/negative ideal solutions to evaluate its relative advantages and disadvantages. The evaluation indexes were initially determined, and their forward trend was ensured. The calculation results are presented in Table 6.

Table 6: Positive and Negative Ideal Solutions

Second-level index No.	Positive ideal solution A+	Negative ideal solution A-
A1	4.494	2.022
A2	4.404	1.995
A3	3.397	1.479
A4	4.638	2.435
B1	5.941	2.855
B2	4.309	2.077
B3	5.779	2.404
B4	6.169	2.581
C1	6.197	2.689
C2	5.004	2.165
C3	5.074	2.167
D1	8.065	3.465
D2	5.228	2.218
D3	5.971	2.489
E1	6.063	2.673
E2	5.319	2.352
E3	6.797	2.957
E4	5.202	2.164

The positive and negative ideal solutions in Table 6 are treated as the middle process values when calculating the positive and negative distances (D+ and D-), which are relatively less significant. Positive ideal solution A+ indicates the maximum value of an evaluation index, while negative ideal solution A- indicates the minimum value of the index.

In Table 6, D+ and D- represent the distances from the evaluation object to the positive and negative ideal solutions, respectively, while C denotes the closeness between the evaluation object and the optimal scheme, with a greater value indicating a greater closeness. Enterprise

Table 7: TOPSIS-based Evaluation of Calculation Results

Item	Positive ideal solution distance D+	Negative ideal solution distance D-	Relative closeness C	Ranking result
Enterprise 1	7.484	8.686	0.537	3
Enterprise 2	7.872	7.477	0.487	10
Enterprise 3	7.672	8.027	0.511	6
Enterprise 4	10.077	6.139	0.379	17
Enterprise 5	8.041	7.146	0.471	13
Enterprise 6	7.66	8.06	0.513	5
Enterprise 7	6.907	7.792	0.53	4
Enterprise 8	6.683	8.629	0.564	2
Enterprise 9	7.868	7.674	0.494	8
Enterprise 10	8.601	8.348	0.493	9
Enterprise 11	7.413	7.664	0.508	7
Enterprise 12	8.32	7.663	0.479	11
Enterprise 13	8.043	7.101	0.469	14
Enterprise 14	6.251	8.57	0.578	1
Enterprise 15	8.831	7.491	0.459	15
Enterprise 16	8.135	7.438	0.478	12
Enterprise 17	9.667	5.597	0.367	18
Enterprise 18	9.082	6.428	0.414	16

14 shows the highest relative closeness (0.578) and ranks first, which indicates that its agricultural products supply chain information system performs best in the comprehensive evaluation. Meanwhile, Enterprise 17 obtains the lowest relative closeness (0.367) and ranks the lowest, which indicates that its agricultural products supply chain information system performs poorly in the comprehensive evaluation.

The relative closeness of Enterprises 14, 8, and 1 is relatively high, indicating that their information management systems perform well in the comprehensive evaluation. This result can be ascribed to the fact that in the agricultural product supply chain, blockchain technology can help enterprises better understand the market demand, optimize their production plans, and reduce their inventory costs. The top-ranking enterprises may make better use of big data technology and realize a digital and intelligent management of supply chains. For instance, Enterprise 14 may analyze the market demand using big data and realize accurate marketing and inventory management, thus improving the comprehensive evaluation score of its information management system. When applied to the agricultural products supply chain, blockchain technology can strengthen the transparency and traceability of information and ensure the quality and safety of agricultural products. These top-ranking enterprises have already adopted blockchain technology and thus have realized information traceability throughout their supply chains from production, processing, and transportation to sales. As a result, consumers have built their trust in the products of these enterprises. Blockchain technology also promotes information sharing and collaboration among various links in the supply chain.

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production, processing, and transportation to sales. As a result, consumers have built their trust in the products of these enterprises. Blockchain technology also promotes information sharing and collaboration among various links in the supply chain.

The above results also confirm that the AHP–CRITIC–TOPSIS model can be used to evaluate the collaboration efficiency among enterprises in the agricultural products supply chain by setting the evaluation indexes for collaborative efficiency (e.g., information sharing degree and collaborative operation efficiency). This model can help enterprises understand their own collaborative efficiency and take the corresponding improvement measures. This model is also simple in principle, easy to understand, and intuitive in its conclusions. Grounded on TOPSIS, the AHP–CRITIC–TOPSIS model provides a new approach for a comprehensive evaluation in other fields.

5 Conclusion

Traditional agricultural products traceability systems, which often rely on paper records or centralized databases, are easily tampered with or damaged, thereby limiting the traceability of information. By using distributed storage and encryption algorithms, blockchain technology ensures the security of data during their transmission and storage and protects the privacy and security of consumers and the quality and credibility of agricultural products. Aiming to solve the core problems being faced by traditional agricultural products supply chain systems, such as information asymmetry, difficulty in traceability, and insufficient data security, blockchain technology was innovatively introduced in this study, and a comprehensive evaluation index for agricultural products supply chain information systems was constructed based on this technology. The supply chain information systems of 18 agricultural products enterprises in China were then comprehensively assessed using the AHP–CRITIC–TOPSIS mathematical model.

The following key conclusions were drawn: (1) blockchain technology significantly improves the performance of agricultural products supply chain information systems and shows enormous potential in improving the efficiency and transparency of supply chains; and (2) the evaluation based on the AHP–CRITIC–TOPSIS mathematical model can effectively promote information collaboration among enterprises in the agricultural products supply chain so as to improve the operational efficiency of the whole supply chain. In the follow-up study, blockchain technology can be further integrated with other advanced technologies, such as big data and artificial intelligence, to establish more efficient and intelligent agricultural products supply chain information systems.

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