

## Research Article

# Modeling the Incentive Mechanism of Information Sharing in a Dual-Channel Supply Chain

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Received 15 May 2021; Revised 12 June 2021; Accepted 12 July 2021; Published 23 July 2021

Academic Editor: Daqing Gong

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Information sharing is the premise of the stable operation and win-win cooperation of the dual-channel agricultural supply chain. To arouse the enthusiasm of information sharing, this paper studies the incentive mechanism of information sharing of dual-channel agricultural product supply chain. The invention problem-solving theory (TRIZ) is adopted to analyze the functional model, the key problems, and the available resources of a dual-channel agricultural supply chain information sharing system. By using the invention principles of the conflict resolution theory, such as separation, precompensation, and feedback, the point bank reward mechanism and the risk evaluation and control mechanism of information sharing are proposed. TRIZ theory provides a new research method and incentive measure for effectively mobilizing the enthusiasm of information sharing.

## 1. Introduction

Information sharing is the premise of the stable operation and win-win cooperation of the dual-channel agricultural supply chain. Producers, suppliers, wholesalers, retailers, and e-commerce of agricultural products have mastered agricultural demand, supply, inventory, forecast, logistics, and other information resources. Only through information interconnection and effective sharing can enterprises trust each other, accurately judge the market, timely grasp the demand, adjust sales strategies, improve the overall efficiency of the supply chain, avoid blind supply and supply interruptions caused by information asymmetry, and avoid the phenomenon of “difficult to sell and expensive to buy” of agricultural products [1]. Information sharing is beneficial for the agricultural products supply chain as a whole, but information sharing has great risks for a single subject. Multiple supply chain subjects are both competitive and cooperative, and each subject hopes to maximize its own interests and minimize risk. Therefore, information sharing may not guarantee a win-win situation for all subjects. Sometimes, it may lead to the loss of channels, disclosure of secrets, and decline of profits for some enterprises [2]. How to enhance the enthusiasm of each subject of agricultural

products supply chain information sharing, effectively avoid risks, and achieve the “win-win” of each subject is the main problem at present.

To solve the above problems, this paper studies the incentive mechanism of information sharing in the dual-channel agricultural supply chain, aiming to mobilize the enthusiasm of each subject in the link for information sharing and improve the overall interests and long-term stability of the agricultural supply chain. At present, the research on the incentive mechanism of information sharing in single-channel or dual-channel agricultural supply chain mainly focuses on trust mechanism, revenue sharing contract, risk assessment, and so on. Research methods such as game model and CVaR criterion have been used, and preliminary results have been achieved [1–15]. Based on the innovative methods in the field of engineering technology, this paper uses the TRIZ theory to carry out research on the incentive mechanism of information sharing. In view of the characteristics of both cooperation and competition of dual channels, this paper uses some inventive principles in the conflict resolution theory to put forward information sharing incentive measures, so as to provide new research methods and incentive means to effectively arouse the enthusiasm of each subject in information sharing.

## 2. Problem Analysis

The theory of inventive problem solving (TRIZ) is used to construct the functional model of the information sharing system of agricultural supply chain and to excavate the key factors and available resources that affect the enthusiasm of information sharing.

*2.1. Functional Analysis.* The information collection, transmission, and sharing support techniques, such as computer, communication technology, Internet, sensor, RFID technology, blockchain, enterprise resource planning system, and others, are used to establish a dual-channel information sharing system for agricultural product supply chain, as shown in Figure 1. The demand, forecast, inventory, and other pieces of information are transferred step by step from downstream to upstream, and the supply, inventory, logistics, and other pieces of information are transferred step by step from the upstream to the downstream. Agricultural product suppliers or other core enterprises use supply chain contract or game theory and other methods to achieve product supply, demand prediction, inventory, logistics, and other types of information resource sharing.

The functional model is established with the government and the market as the supersystem originals, the shareable information as products, and the information circulation system, information sharing technology, and information sharing hardware as the technical system [16], as shown in Figure 2.

We can get the factors that influence information sharing, such as insufficient market drive to information sharing, excessive market block to information sharing, and lack of technical support for information sharing.

*2.2. Root Cause Analysis.* Causal chain analysis was used to analyze the key reasons (circled by the dotted ellipse) for the inactive information sharing, as shown in Figure 3.

Among them, “the core enterprise occupies a dominant position” can be solved by using schemes such as revenue sharing contracts. “Technology, funds, and policies are not in place” can be solved by increasing the development of information sharing technology, capital investment, government policy support, and other solutions. “Personnel training is not in place” can be solved by increasing the number of types of training, enriching training mode, and other solutions. Therefore, “incomplete and lagging incentive measures after information sharing” and “insufficient risk evaluation before information sharing,” which have no specific solutions at present, are the key points of the problem.

*2.3. Available Resource Analysis.* In view of the key points of the problem, the available resources (material resources and field resources) are analyzed from the internal and external aspects of the system to establish a resource list [15], as

shown in Table 1, providing reference for the generation of subsequent schemes.

## 3. Choice of Innovative Tools

TRIZ theory provides a set of technology innovation theories and methods and a set of tools to solve all kinds of engineering technical problems. It systematically summarizes human’s previous ideas on invention and innovation and extracts a series of effective rules to guide people to solve innovation problems efficiently. TRIZ also has a good guiding effect on solving problems in the social domain. Conflict resolution theory, matter-field analysis, and technological evolution are the commonly used innovation tools in TRIZ [16].

*3.1. Tool Selection Analysis.* From the perspective of the overall cooperation and long-term stability of the dual-channel supply chain, information sharing is imperative. However, for a certain enterprise, information sharing is a double-edged sword with both advantages and disadvantages, and not all subjects are willing to take the initiative to participate in information sharing. Cooperation and competition coexist among farmers, production bases, wholesalers, retailers, and e-commerce platforms. Both their independent interests and the overall interests of the supply chain should be taken into account. Information sharing can help enterprises better control market demand and bring greater profits. At the same time, it is possible to make the same or less profit before and after the sharing of information. In this way, the enterprise’s own interests have been damaged, even corporate secrets have been leaked, and the channel has been lost. There are obvious interest conflicts and channel conflicts between online and offline and upstream and downstream subjects. Information sharing may not achieve a win-win situation for all subjects and may not consider overall interests and individual interests, long-term interests, and short-term interests. Therefore, information sharing becomes a process of repeated games. Core enterprises, which play a dominant role in the supply chain, have the right of profit distribution and are more willing to initiate information sharing. What is more, it will take some measures to stop business dealings and intimidate other enterprises to share information [2]. Other companies are forced to share information, not voluntarily. There are obvious conflicts of interest and channel conflicts in dual-channel supply chain. This paper adopts conflict resolution theory to carry out innovative research on information sharing incentive mechanism.

*3.2. Introduction to the Theory of Conflict Resolution.* The problem of inactive information sharing in the supply chain can be solved by using the principle of technical conflict in conflict resolution theory. To resolve technical conflicts, TRIZ theory combines principles from the fields of physics, chemistry, and engineering and proposes 40 principles of invention that have been repeatedly used by inventions in different eras and fields, such as segmentation, extraction,

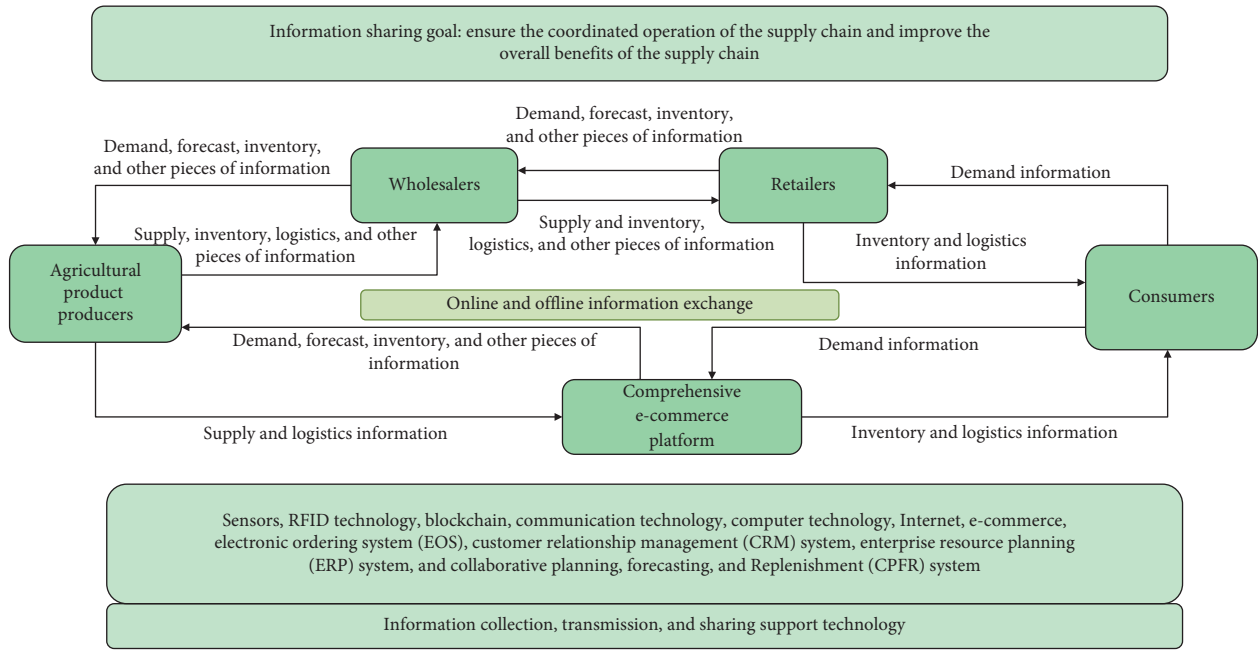


FIGURE 1: Dual-channel information sharing system of agricultural product supply chain.

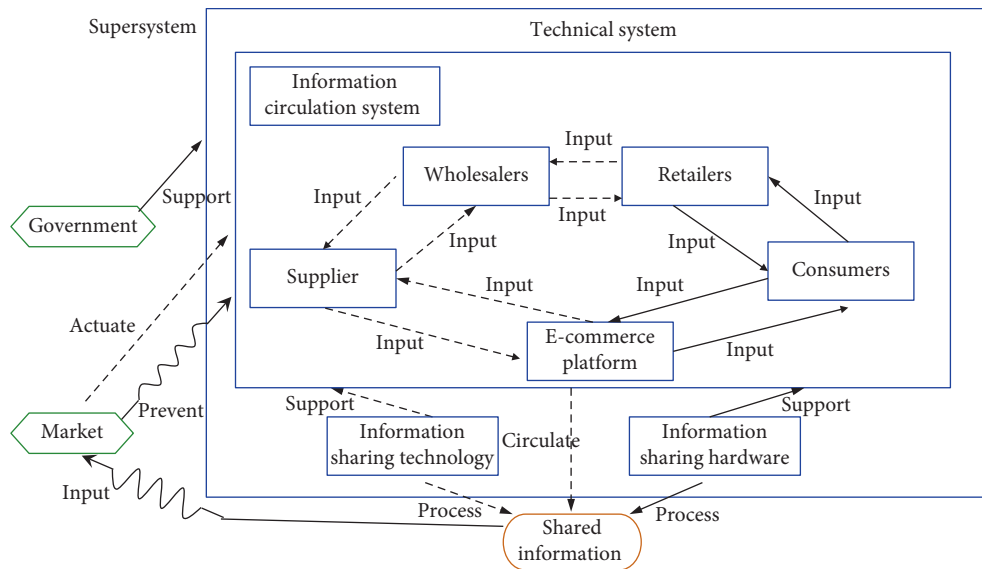


FIGURE 2: Functional model of information sharing system for dual-channel agricultural product supply chain.

local mass, asymmetry, merger, versatility, preoperation, dynamic, package, reverse, feedback, precompensation, abandonment, and repair [16].

3.3. *Application of the Principles of Invention.* Considering the five schemes in Table 2, and aiming at the key problems of “imperfect information sharing incentive measures” and “insufficient risk evaluation before information sharing,” from the perspective of benefits and risks, schemes 1 and 2 were integrated into “information sharing risk evaluation and prevention mechanism,” and schemes 3, 4, and 5 were integrated into “information sharing credit bank reward mechanism.”

#### 4. Point Bank Reward Mechanism of Information Sharing

The effective behavior of sharing information of enterprises will be converted into points, and the point system will be introduced to provide timely feedback and effective rewards to enterprises participating in information sharing.

- (1) The generation of points: the amount of information, accuracy, timeliness, and duration of the enterprise’s shared information will be converted into points. With the continuous sharing of information, the points will continue to grow and be deposited into the enterprise’s account in the point bank.

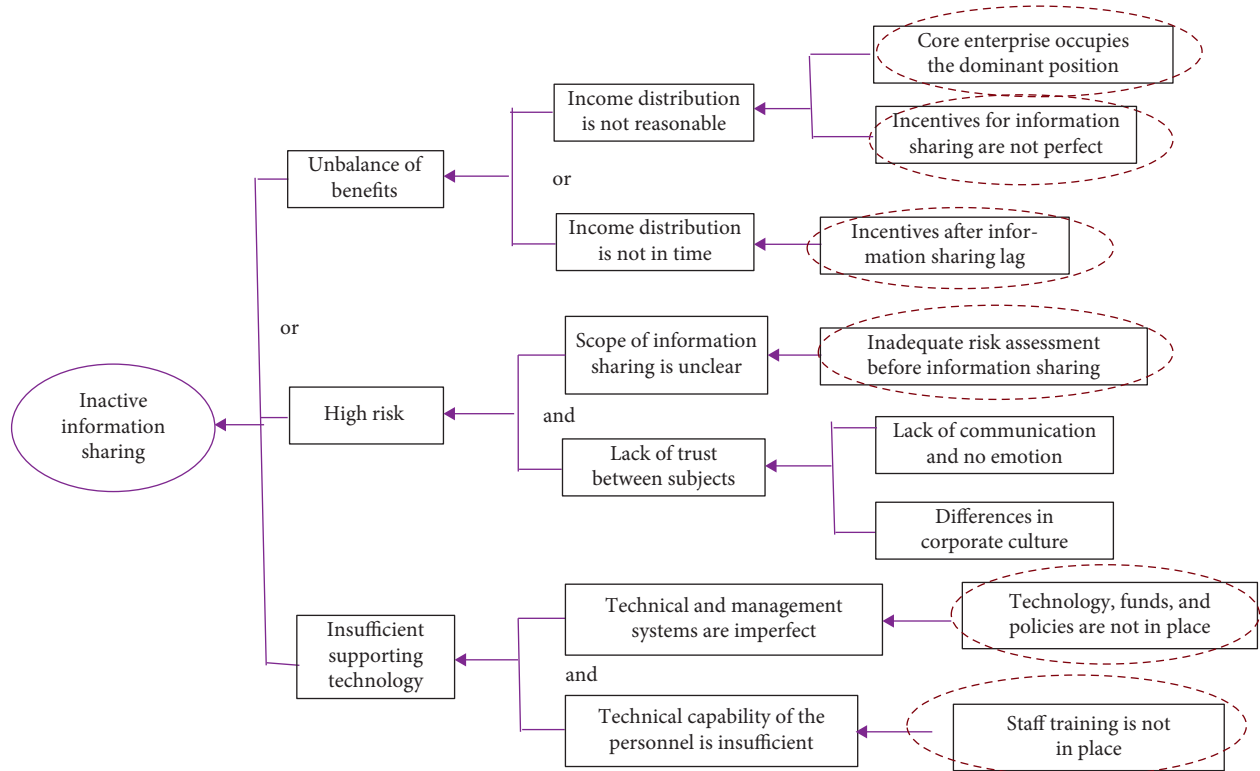


FIGURE 3: Diagram of causal chain analysis.

TABLE 1: List of available resources.

Category	Name of resource	Available attribute parameter	Usability analysis
System internal material resources	Subjects of supply chain (suppliers, wholesalers, retailers, and e-commerce platform)	Amount of information mastered	Determine information type and accuracy
		The amount of information that can be shared	Assess the level of information sharing
	Information sharing technology, management systems, and hardware	Advancement	Enriching information sharing technology
		Security	Strengthen security prevention and control of information sharing
System internal field resources	Dual-channel supply chain	Integrated	Integration management system to achieve docking
		Flexible	Enhance the flexibility of supply chain
		Agility	Quickly respond to market needs
System external material resources	Market economy environment	Stability	Maintain long-term sustainable operations
		Openness	Open the market wider
	Government	Competitive	Make rational use of market competition
		Strength of support	Introduce supporting policies and fund investment
System external field resources	Internet + e-commerce	Maturity	Improve the e-commerce operation environment
	Economic benefit	Fairness	Reasonable distribution of economic benefits
System external field resources	Market risk	Influence	Achieve social benefits in time
		Hazardous	Try to reduce harm
		Evaluability	Evaluate the level of risk reasonably

TABLE 2: Some schemes based on the principle of invention.

Scheme	The corresponding invention principle	Scheme described
1	No. 3 “local quality,” article 2	Classify the information in the dual-channel supply chain according to the risk level. Information of different risk levels should be shared in different ways
2	No. 10 “preoperational”	Before information sharing, the risk evaluation process of information sharing should be established to assess the risk level of information in advance
3	No. 11 “precompensation”	Formulate emergency measures to compensate for the losses caused by the disclosure of enterprise trade secrets due to improper information sharing
4	No. 15 “dynamic,” article 1	Formulate the information sharing strategy suitable for the market environment and timely evaluate and adjust the encouragement measures
5	No. 23 “feedback,” article 1	After information sharing, feedback and incentives should be given to enterprises in time, and incentive measures should be established to encourage enterprises to share information effectively in the long term

- (2) The rules of points: if the information shared can generate significant economic benefits, the points can be doubled. On the contrary, points will be deducted if false information is shared or the information is not shared for a long time.
- (3) The level of points: the user level of the enterprise in the information sharing credit bank is classified according to the number of points. The more the points, the better the credit rating of the enterprise. The credit rating of an enterprise in an integral bank will be linked to its credit rating in an entity bank, and certain consideration will be given when the enterprise deals with loans and other businesses. Banks can offer certain preferential policies to enterprises with high ratings.
- (4) The usage of points: drawing on the idea of point exchange in real business, point banks should formulate a set of point exchange rules. Points can be exchanged for information needed by the enterprise, exchanged for information from other channels, or exchanged for opportunities to participate in business activities, or exchanged for opportunities to cooperate with other organizations, or points can be used to properly compensate for losses caused by disclosure of information by enterprises caused by improper information sharing.

It is worth emphasizing that each subject of the supply chain should appoint 1-2 representatives to form the information sharing point group to evaluate the amount of information, accuracy, timeliness, and value of sharing of enterprise shared information. It is suggested to use evidence theory to convert scores into points, eliminate inconsistencies of multiple scores representing multiple scores, and eliminate conflicts of evidence (evaluation information). D-S evidence synthesis method is used to conduct information fusion processing for each representative’s score. Multiple pieces of evidence (multiple evaluation information) are systematically processed to generate basic probability distribution function and comprehensive evaluation value, as shown in formula (1). Finally, the comprehensive evaluation value weighting of multiple representatives for a certain subject of a supply chain project on all indicators is added up, that is, converted into points.

Assume that  $Bel_1, Bel_2, \dots, Bel_n$  are the belief functions in the same recognized frame  $\Omega$ ,  $m_1, m_2, \dots, m_n$  are the corresponding basic probability assignments, and  $A_i, A_j, A_k, \dots$  are the corresponding focal elements. Then, the belief function  $Bel$  combined by  $Bel_1, Bel_2, \dots, Bel_n$  can be calculated by the following basic probability assignment function  $m$ :

$$m(A) = \begin{cases} 0, & A = \phi, \\ \sum_{A_i \cap A_j \cap A_k \cap \dots = A} m_1(A_i)m_2(A_j)m_3(A_k) \dots + Kq(A), & A \neq \phi, \end{cases} \tag{1}$$

where  $K = \sum_{A_i \cap A_j \cap A_k \cap \dots = \phi} m_1(A_i)m_2(A_j)m_3(A_k) \dots$ ,  $K$  represents the degree of conflict between pieces of evidence;  $q(A) = (1/n) \sum_{1 \leq i \leq n} m_i(A)$ ,  $m(A)$  reflects the credible degree to  $A$  itself [17].

In the process of the implementation of the point reward mechanism, the information sharing point team should pay close attention to the dynamic changes of the market environment, organize the communication and cooperation between online and offline enterprises, and adjust their marketing strategies in time.

## 5. Risk Evaluation and Control Mechanism of Information Sharing

- (1) Clarify the object of information sharing risk evaluation. Agricultural product suppliers, wholesalers, retailers, and traders have the agricultural product demand information, supply information, inventory information, forecasting information, logistics information, etc.
- (2) Clarify the subject of information sharing risk evaluation. The joint risk prevention and control

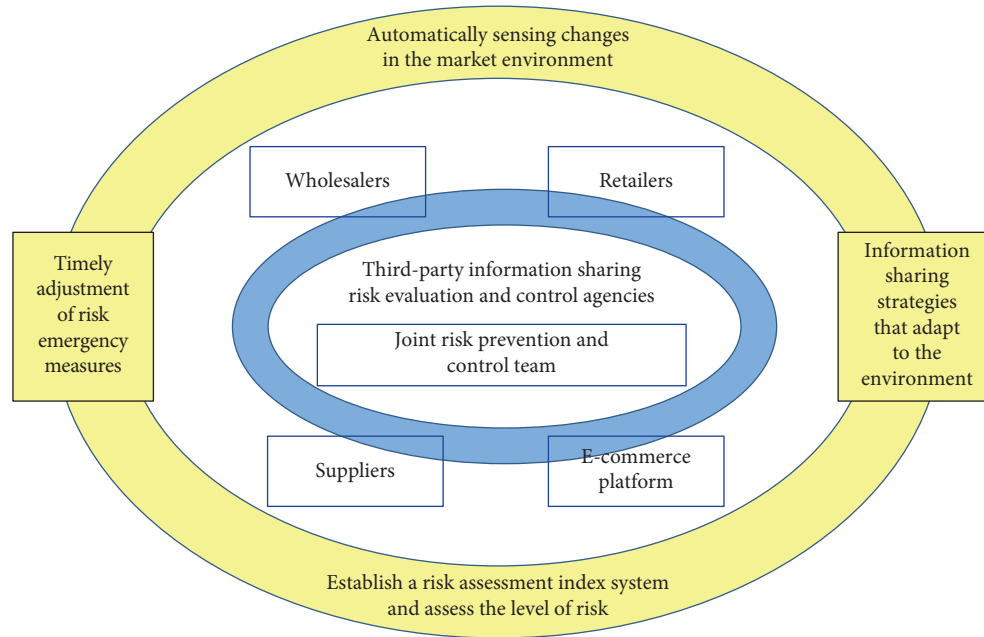


FIGURE 4: Risk evaluation and control mechanism of information sharing.

team is jointly established by representatives of various supply chain entities and third-party risk evaluation and control agencies. The team is responsible for analyzing supply chain risk, giving comprehensive evaluation value, and jointly implementing risk evaluation.

- (3) Determine the timing of the evaluation. After the formation of the dual-channel supply chain for agricultural products, the risk evaluation of information sharing should be carried out. When the market environment of agricultural products fluctuates greatly, the risk evaluation should be reconducted.
- (4) Build evaluation index system. The indexes such as information accuracy, information importance, information chain effect, individual profit increment after sharing, intrachannel profit increment after sharing, overall profit increment after sharing, individual loss after sharing, intrachannel loss after sharing, and possibility of channel loss after sharing are mainly considered.
- (5) Implement risk grade evaluation. The third-party information sharing risk evaluation and control institutions dominated information sharing. Before and after the information sharing of agricultural supply chain, the information sharing risk evaluation index system is established and the risk level is evaluated.
- (6) Establish the risk evaluation and control mechanism. Under the leadership of the third-party risk evaluation and control agency, the joint risk prevention and control team will automatically respond to changes in the market environment, establish the dynamic risk evaluation mechanism, develop

information sharing strategies suitable for the market environment, and adjust risk prevention and control measures in a timely manner, as shown in Figure 4.

## 6. Conclusions

This paper analyzed the incentive problem of information sharing in dual-channel agricultural products supply chain using TRIZ theory, innovated the point bank reward mechanism and the risk evaluation and control mechanism for information sharing, and solved the key problems such as “imperfect incentive measures after information sharing” and “insufficient risk evaluation before information sharing.” It provided a new solution and practical means to arouse the enthusiasm of information sharing. In addition, the root cause and available resource analyses in this paper are not comprehensive enough and need to be further improved. In the following research, the analysis of available resources will be improved from the aspects of new business forms, new models, and digital economy. It is necessary to dig the guarantee mechanism of agricultural supply chain in order to perfect the root cause analysis. In the following research, representative regional supply chains of agricultural products should be selected to carry out the example verification of information sharing mechanism to prove the reliability of the theory. Due to the limitation of the research level, there are still some defects in the point bank reward mechanism and the risk evaluation and control mechanism for information sharing. The way of exchanging points between online and offline channels is not flexible enough, and the selection of third-party agencies to undertake risk assessment and control of information sharing lacks a standardized process.

## Data Availability

The data used in this article were obtained from CNKI (China National Knowledge Infrastructure) [https://www.cnki.net/?UID=WEEvREcwSljHSldTTEYzWEpEZkxoaKxCc1l6SHVHM0ZjeTZtc2Y3T1c1VT0%3d%249A4hF\\_YAuvQ5obgVAqNKPCYcEjKensW4IQMowHtwkF4VYPoHbKxJw!~::~::~::~::~::~::~::~::~::~::~&autoLogin=1](https://www.cnki.net/?UID=WEEvREcwSljHSldTTEYzWEpEZkxoaKxCc1l6SHVHM0ZjeTZtc2Y3T1c1VT0%3d%249A4hF_YAuvQ5obgVAqNKPCYcEjKensW4IQMowHtwkF4VYPoHbKxJw!~::~::~::~::~::~::~::~::~::~::~&autoLogin=1).

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Acknowledgments

This research was supported by the Doctoral Foundation Project of Hebei College of Industry and Technology (bz2020003).

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