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Research on Blockchain-driven Agricultural Products E-commerce Supply Chain Innovation under Game Perspective

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Abstract

With the arrival of the big data era, digital technology has achieved an unprecedented development speed, and blockchain, as a representative of digital technology, solves the problem of mutual trust between multiple transaction subjects in different scenarios with the technological advantages of decentralisation, timestamping and non-tampering. Currently, in the agricultural products e-commerce supply chain scenario, there is the problem of credit risk of agricultural products producers and sellers. Aiming at the pain points of agricultural products e-commerce supply chain, this paper analyses from the perspective of game, through blockchain incentive mechanism, and puts forward blockchain-driven agricultural products e-commerce supply chain innovation suggestions.

Keywords

Gaming, agricultural e-commerce, blockchain, supply chain

1. Introduction

As digital technologies represented by artificial intelligence, big data, cloud computing and blockchain are widely applied to various scenarios in agriculture, digital development has become a new driving force for agricultural transformation. The report of the Twentieth National Congress on 16 October 2022 explicitly proposed to promote the development of integrated clusters of strategic emerging industries, and to build a number of new growth engines such as new-generation information technology, artificial intelligence and so on. The report of the 20th National Congress on 16 October 2022 explicitly proposed to promote the integration and cluster development of strategic emerging

industries, build a number of new growth engines such as new-generation information technology and artificial intelligence, and promote the in-depth integration of modern service industries and modern agriculture. Among the new generation of information technology, blockchain technology has become an important application to promote the transformation and development of agriculture with the advantages of decentralisation, timestamping, and non-tampering.

In the process of agricultural transformation and development, the marketing of agricultural products is particularly important. In order to give full play to the role of the market economy, agricultural products must be brought to the market to meet consumer demand. In the popularity of "Internet +" today, e-commerce has become an important channel for the sale of agricultural products with the advantage of its convenience. However, in the practical application of agricultural e-commerce, there is still the problem of credit default of business entities. In the future, the use of blockchain technology to solve the problems of agricultural e-commerce and drive the innovation of agricultural e-commerce supply chain has become a feasible new path.

2. Problems in the E-commerce Supply Chain for Agricultural Products

E-commerce of agricultural products refers to the use of modern networks to engage in the sale of agricultural products. The current application of agricultural products e-commerce is still in the primary stage of development, the information asymmetry between the market players, so that there are some confusions in the process of agricultural products e-commerce development, which seriously impedes the development of agricultural products e-commerce supply chain. There are mainly the following three problems:

2.1 Inadequate Supply Chain Information-sharing Mechanisms

Ji (2012) that the interest-driven factors affect the benign development of the supply chain information sharing mechanism, the supply chain in which each participant can obtain the benefits of the supply chain is the basic conditions of the supply chain is sustainable. Agricultural products producers, transporters and sellers have not formed a unified production and marketing operating system, information sharing standards and information collection platforms are inconsistent, there is information asymmetry in the various operational aspects of agricultural products e-commerce, low information transparency, high data barriers, consumers in the e-commerce platform can not make an effective judgement of the quality of agricultural products, and many consumers tend to choose the traditional offline way to buy Many consumers tend to choose the traditional offline way to buy agricultural products, which restricts the development of agricultural e-commerce.

2.2 Poor Quality of Data Collected

Various enterprises in the agricultural supply chain use different systems, and when the agricultural e-commerce supply chain collects data, due to factors such as uneven system data collection capabilities, differences in statistical calibre, and artificial counterfeiting, invalid, omitted, and distorted data on the chain occur from time to time, resulting in a lack of credibility of data on the agricultural

e-commerce supply chain, which has a direct impact on the willingness of consumers to purchase agricultural products through the e-commerce platform.

2.3 Lack of Effective Management of E-commerce in Agricultural Products

Although there is relevant legislation on e-commerce in China, due to the fact that agricultural e-commerce involves more links in the whole supply chain from production to sales, there are often difficulties in tracing the responsibility for the quality of agricultural products and ambiguous positioning of the responsibility, resulting in the ecology of the e-commerce supply chain being seriously undermined.

The above problems pose serious challenges to the development of e-commerce supply chain for agricultural products and directly affect the development of agricultural modernisation.

3. Agricultural Products E-commerce Supply Chain Game Model

Agricultural products e-commerce supply chain consists of consumers, sellers, transporters, producers, e-commerce platforms and government regulators. Consumers have the right to choose agricultural e-commerce, and their willingness to consume agricultural products through e-commerce channels depends on the credibility of the agricultural e-commerce supply chain, and the after-sales service of agricultural e-commerce has a positive impact on the credibility of the supply chain. Therefore, this paper starts the research from the after-sales service of agricultural products e-commerce.

F-commerce after-sales service for agricultural products is one of the most important factors in determining consumer satisfaction, assuming that government regulators fulfill their regulatory duties properly and e-commerce platforms fulfill their responsibilities in a compliant manner. When the quality of agricultural products purchased by consumers through e-commerce is in question, the main body of responsibility for the accident may arise from one of the agricultural product producers, transporters and sellers. Since the transporter serves the seller, this paper combines the seller and the transporter into a single responsible body, the seller.

The producer of the agricultural products enters into a formal purchase and sale agreement with the seller, whereby the producer is responsible for the quality of the agricultural products it produces and bears responsibility for the after-sales service, and the seller is the part in interest. The seller sells the purchased agricultural products through the e-commerce channel to the consumers and bears the liability, and the interested part is the consumers. When the quality of the agricultural products sold through the e-commerce channel has problems, a chain of responsibility is formed in which the consumer seeks to recover responsibility from the seller, and the seller seeks to recover responsibility from the producer.

3.1 Game Model Assumptions

It is assumed that the agricultural products e-commerce producers and sellers are the opponents of the game, and it is assumed that both sides of the game are rational economic beings, aiming at the pursuit of their own benefit maximisation. When the agricultural products e-commerce supply chain reaches

the condition of triggering the agricultural products e-commerce after-sales service, both parties of the game have the following two choices respectively:

3.1.1 The producer, as the after-sales service handler, can choose to perform or default. When the manufacturer chooses to perform, it protects consumer satisfaction, and the manufacturer also receives the indirect benefit of increased creditworthiness for actively performing after-sales services; when the manufacturer defaults, the seller will pursue the manufacturer, and the manufacturer will be liable to the seller.

3.1.2 Sellers, as the responsible part for after-sales service, do not need to take responsibility when the manufacturer performs, and can obtain the indirect benefit of credit enhancement; when the manufacturer breaches the contract, the consumer will pursue the responsibility to the seller, and the seller will take the responsibility to compensate the consumer, and at the same time, the seller will pursue the responsibility to the manufacturer. In the case of consumer liability, the seller can choose to offer compensation to the consumer or refuse to do so.

The choice of default by either producers or sellers is a breach of trust in the agricultural e-commerce supply chain, and consumers will lose trust in agricultural e-commerce, which will have an impact on the sustainable development of the agricultural e-commerce supply chain.

3.2 Game Model Analysis

Assuming that the probability of manufacturer's performance is r_1, the probability of default is $1-r_1$; assuming that the probability of seller's performance is r_2, the probability of default is $1-r_2$. There are four types of game behaviours of the manufacturer and the seller:

3.2.1 The producer performs and the seller performs. The producer can obtain long-term orders and potential orders from sellers, the future revenue obtained is $\sum_{i=1}^{n} R_i$, and the future credit revenue obtained from potential orders from other sellers is $\sum_{i=1}^{n} Q_i$, and the after-sale fulfillment cost paid is $\sum_{i=1}^{n} A_i$, then the revenue obtained is $\sum_{i=1}^{n}(R_i+Q_i-A_i)$; in the case of seller's fulfillment, the fulfillment cost is borne by the producer, and the seller has no additional cost. The seller obtains consumers' trust, and the brand effect generates a future gain of $\sum_{i=1}^{n} L_i$, and there is no additional cost to the seller, so the seller's gain from performance is $\sum_{i=1}^{n} L_i$。

3.2.2 The producer performs and the seller defaults. The seller withdraws from the market due to unsustainable subsequent sales revenue from breach of contract, the producer cannot obtain future orders from the seller, but good credit can obtain potential orders from other sellers gain $\sum_{i=1}^{n} Q_i$, pay after-sale performance cost $\sum_{i=1}^{n} A_i$, then the gain obtained is $\sum_{i=1}^{n}(Q_i-A_i)$; in the case of seller breach of contract, the gain obtained from the regulatory authority's penalties is $-\sum_{i=1}^{n} N_i$, in addition, compliance and default give different levels of experience to consumers, the brand effect gain $-\sum_{i=1}^{n} M_i$, and the final gain $-\sum_{i=1}^{n}(N_i+M_i)$.

3.2.3 The producer defaults and the seller performs. The producer will lose the long-term order from the seller and be held liable by the seller, the gain is $-\sum_{i=1}^{n} R_i$, the credit gain due to the brand effect caused by the default is $-\sum_{i=1}^{n} S_i$, and the final gain by refusing to fulfill the contract is $-\sum_{i=1}^{n}(R_i+S_i)$; the

seller will have to bear the cost is the producer's cost of performance $\sum_{i=1}^{n}A_i$, and the gain is the branding effect $\sum_{i=1}^{n}L_i$ and the gain from holding the manufacturer liable $\sum_{i=1}^{n}R_i$, and the final gain is $\sum_{i=1}^{n}(L_i+R_i-A_i)$.

3.2.4 The producer defaults on the contract and the seller defaults on the contract. On the producer's side, the gain from being held accountable by the seller is $-\sum_{i=1}^{n}R_i$, the credit gain from the impact of the brand due to default is $-\sum_{i=1}^{n}S_i$,and the final gain from refusing to fulfill the contract is $-\sum_{i=1}^{n}(R_i+S_i)$; on the seller's side, the gain from the penalty imposed by the regulator is $-\sum_{i=1}^{n}N_i$, and the gain from holding the producer accountable for breach of contract is $\sum_{i=1}^{n}R_i$. The gain from the impact of the brand is $-\sum_{i=1}^{n}M_i$,and the final gain is $-\sum_{i=1}^{n}(N_i+M_i-R_i)$.

Based on the above analyses, through the game study methodology, a payoff matrix can be derived, as shown in Table 1:

Table 1. Revenue Matrix

proceed		marketer	
		honour a contract r_2	breach of contract $1-r_2$
producers	honour a contract r_1	$\sum_{i=1}^{n}(R_i+Q_i-A_i)$, $\sum_{i=1}^{n}L_i$	$\sum_{i=1}^{n}(Q_i-A_i)$, $-\sum_{i=1}^{n}(N_i+M_i)$
0	breach of contract $1-r_1$	$-\sum_{i=1}^{n}(R_i+S_i)$, $\sum_{i=1}^{n}(L_i+R_i-A_i)$	$-\sum_{i=1}^{n}(R_i+S_i)$, $-\sum_{i=1}^{n}(N_i+M_i-R_i)$

As rational economic agents tend to participate in the supply chain for long-term benefits, the hypothesis applies to the long-term multiple game assumption.

On the one hand, analysed from the producer's point of view, the producer's revenue expectation is affected by the seller's strategy, and assuming that the producer's performance revenue expectation is E_1 and default revenue expectation is E_2, the expectation equation is:

$E_1=r_2\sum_{i=1}^{n}L_i+(1-r_2)[-\sum_{i=1}^{n}(N_i+M_i)]$

$E_2=r_2\sum_{i=1}^{n}(L_i+R_i-A_i)+(1-r_2)[-\sum_{i=1}^{n}(N_i+M_i-R_i)]$

When the value of performance is greater than or equal to the value of default, the producer receives a long-term gain and is willing to fulfil the contract, then we have: $E_1 \gg E_2$

$r_2\sum_{i=1}^{n}L_i+(1-r_2)[-\sum_{i=1}^{n}(N_i+M_i)] \gg r_2\sum_{i=1}^{n}(L_i+R_i-A_i)+(1-r_2)[-\sum_{i=1}^{n}(N_i+M_i-R_i)]$

The simplification is obtained: $r_2\sum_{i=1}^{n}A_i \gg \sum_{i=1}^{n}R_i$

$r_2 \gg \sum_{i=1}^{n}(A_i/R_i)$

The above analysis shows that the default rate r_2 is a positive number with values from 0 to 1. The smaller the numerator $\sum_{i=1}^{n}A_i$ and the larger the denominator $\sum_{i=1}^{n}R_i$ in the equation, the more likely it is that the equation will hold. The conclusion is that the smaller the producer's cost of performance and the larger the benefit of performance, the more favourable it is for the producer to fulfill the contract and the supply chain to operate sustainably.

On the other hand, analysing from the seller's point of view, the expected value of the seller's return is affected by the producer's strategy, assuming that the seller's expected value of the return on

performance is E_3 and the expected value of the return on default is E_4, since the expected value equation is regardless of whether the seller defaults or not:

$E_3=r_1\sum_{i=1}^{n}(R_i+Q_i-A_i)+(1-r_1)[-\sum_{i=1}^{n}(R_i+S_i)]$

$E_4=r_1\sum_{i=1}^{n}(Q_i-A_i)+(1-r_1)[-\sum_{i=1}^{n}(R_i+S_i)]$

When the value of performance is greater than or equal to the value of default, and the seller receives a long-term gain and is willing to fulfill the contract, then we have: $E_3 \gg E_4$

$r_1\sum_{i=1}^{n}(R_i+Q_i-A_i)+(1-r_1)[-\sum_{i=1}^{n}(R_i+S_i)] \gg E_4=r_1\sum_{i=1}^{n}(Q_i-A_i)+(1-r_1)[-\sum_{i=1}^{n}(R_i+S_i)]$

The simplification is obtained: $\sum_{i=1}^{n}R_i \gg 0$

The above analysis shows that when the producer's performance benefit is greater than 0, the producer is willing to perform, and the seller will be able to reap the long-term benefits of the supply chain.

4. Blockchain-driven Agricultural Products E-commerce Supply Chain Innovation Countermeasures

The responsibility of the main body of the agricultural e-commerce supply chain is traced on the basis of the authority of the e-commerce platform, and the application of blockchain technology is conducive to maintaining the authority of the e-commerce platform. The application of blockchain technology in agricultural products e-commerce has three main advantages: first, decentralisation, the technology can avoid the credit risk of agricultural products e-commerce trading platform, and simplify the risk of agricultural products e-commerce into the supply chain risk between the producers, sellers and consumers; second, timestamping, the technology can be traced back to the e-commerce platform for every transaction record and transaction time, which is conducive to Distinguish the responsibility of the main body of the transaction; Third, the tampering, the use of the technology can ensure that each piece of data can not be tampered with to ensure the authenticity of the record. In addition, the full use of "blockchain + agricultural e-commerce" can further promote the fulfilllment of responsibilities of all business entities in the chain and maintain the sustainable development of the agricultural e-commerce supply chain through the following aspects.

4.1 Improving the Information Sharing Mechanism of Agricultural Products E-Commerce Supply Chain

The game hypothesis is built on the basis that the information of the agricultural e-commerce supply chain can be completely shared. The use of blockchain technology can realise the sharing of transaction information on the chain, thus effectively restraining agricultural products e-commerce producers and sellers. In the process of implementation, government departments, technology companies, e-commerce platforms, agricultural products producers, and agricultural products sellers need to cooperate with each other.

In terms of support from government departments, the legal department has made it clear that the corroborating information provided by blockchain technology is legally recognised by legislating on blockchain-related provisions; and the industry and information department has promoted the

popularity of blockchain in e-commerce platforms through the Information Technology Construction Organisation.

In terms of support from tech companies, tech companies need to continuously improve the security of blockchain technology so as to enhance the credibility of blockchain technology in the e-commerce supply chain of agricultural products.

In terms of e-commerce platform support, e-commerce platforms need to abandon their inherent thinking, actively introduce blockchain technology into platform use, and continuously improve the use of blockchain technology in agricultural e-commerce platforms.

With regard to the support of agricultural product producers and sellers, agricultural product producers and sellers, as the main operating bodies of the supply chain, their support for the use of blockchain technology in the agricultural product e-commerce platform is conducive to further promoting the construction of agricultural product e-commerce informatisation. Both sides of the game can use blockchain technology to understand the relevant information of the game opponents while operating legally, so as to take effective measures to safeguard their legitimate rights and interests.

4.2 Improving the Quality of Data Collection in Agricultural E-commerce

Improvement in the quality of data collection helps to enhance the credibility of agricultural e-commerce platforms, and therefore requires e-commerce platforms for agricultural products to form effective incentives and constraints for producers and sellers to improve the motivation of producers and sellers to fulfill their obligations.

From the perspective of performance benefits, the e-commerce supply chain of agricultural products has to maintain sustainable development. On the producer side, the larger the performance benefit and the smaller the performance cost, the more the producer's willingness to perform will be increased; on the seller side, as long as the producer's performance benefit is positive, the seller's motivation to perform will be higher.

From the perspective of default benefits, agricultural e-commerce supply chains have to remain sustainable. On the producers' side, the greater the cost of default, the more it reduces the producers' willingness to default; on the sellers' side, default cannot bring them positive benefits, and the sellers tend to urge producers to fulfill their contracts.

Improving the quality of data collection on agricultural e-commerce is conducive to increasing incentives and constraints for e-commerce operators. It is necessary for government regulators, e-commerce third-part platforms and technology companies to form a joint effort to create a favourable e-commerce supply chain environment. The government regulators should raise the requirements on data collection quality, strengthen the supervision on the authenticity, timeliness and completeness of e-commerce data collection work, and further strengthen the management of data collection constraints and incentives for the participating market entities; the e-commerce third-part platform should make full use of blockchain technology to improve the efficiency of data collection; and the science and technology companies should further enhance the scientific and technological content of the blockchain

technology. Enhance the ability of science and technology innovation to support the innovation of agricultural e-commerce.

4.3 Strengthening Credit Regulation of Agricultural E-commerce

The government side should further improve the social credit system and strengthen the credit management of agricultural e-commerce subjects. In terms of constraints, firstly, the agricultural credit system and e-commerce credit system should be effectively integrated and information sharing to avoid regulatory blind spots; secondly, the default behaviour of agricultural product e-commerce business subjects should be incorporated into the social credit supervision system to further increase the credit supervision of agricultural product e-commerce supply chain. In terms of incentives, government departments should establish databases and give preferential policies to honest enterprises in agricultural e-commerce in terms of credit and taxation, so as to strongly incentivise trustworthy behaviour and support the development of agricultural e-commerce.

Therefore, through the common role of agricultural e-commerce market players, the use of blockchain technology to provide support for the benign development of the agricultural e-commerce supply chain, further promote the development of digital agriculture, thereby promoting the integration of digital countryside and modern agriculture.

Fund projects

1. 2023 Guangxi University Young and Middle-aged Teachers' Scientific Research Basic Ability Enhancement Project (2023KY1795): 'Guangxi Digital Countryside and Modern Agriculture Integration and Development Research Based on Blockchain Application'.

Development Research";

2. 2021 Guangxi Young and Middle-aged Teachers' Scientific Research Basic Ability Enhancement Project in Colleges and Universities in Guangxi (2021KY1731): 'Exploring the Integration of Blockchain Technology and Financial Services in Guangxi';

3. 2024 Guangxi University Young and Middle-aged Teachers' Scientific Research Basic Ability Enhancement Project (2024KY1957): 'Research on Rural Financial Risk Management and Decision Making in Guangxi Based on Augmented Learning Algorithm';

4. The 2022 Teaching and Research Project (2022JY08) of Shiyuan College, Nanning Normal University: "Exploration and Reform of Talent Training System for Financial Engineering Major in the Context of New Liberal Arts Construction".

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