Research on the Application of Blockchain Technology in the Innovative Development of Agricultural Supply Chain Finance

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Abstract: Supply chain finance can provide high-quality financing channels for agriculture, rural areas and farmers to support the development of agricultural industry chain, but agricultural supply chain finance has not reached the maturity in the industrial field, the agricultural supply chain structure is loose, the enterprise qualification is quite different, the agricultural industry itself has a special attribute determines the agricultural and industrial supply chain finance innovation mechanism is significantly different. This paper analyzes the construction method of embedding the key technology of blockchain into agricultural supply chain finance to solve the problems of "difficult financing, expensive financing and slow financing" of agriculture-related smes from the technical level. Combined with the characteristics of agricultural cooperatives, a "1+1+N" supply chain finance architecture was proposed to solve the problem of loose structure of agricultural supply chain from the management level, and the agricultural supply chain finance model was innovated on a sub-basis by combining blockchain technology. Shapley value method was used to construct the financial benefit distribution model of agricultural supply chain, and the incentive mechanism of participating enterprises in supply chain finance was discussed by means of the benefit distribution model. The research results enrich the application of blockchain in the fields related to agricultural supply chain finance, and contribute to the establishment of supply chain financing environment for small, medium and micro agriculture-related enterprises based on cooperatives, thus contributing to rural revitalization.

1 INTRODUCTION

According to the data from the Blue Book of Internet Finance for "Agriculture, Countryside and Farmers" released by the Chinese Academy of Social Sciences, the financial gap for "agriculture, countryside and farmers" in China has reached 3.05 trillion yuan, and there is still much room for improvement in the revitalization of financial services for rural industries. At present, China's rural financial resources are seriously deficient. The systems of rural homestead mortgage, agricultural product mortgage, rural land contractual management right mortgage, and agricultural product insurance are not perfect. Small, medium-sized and micro agricultural enterprises and farmers have limited financing channels, large financing difficulties, long financing cycle, and high financing costs. These problems are closely related to the existing supply chain status of agricultural enterprises.

2 LITERATURE REVIEW

Ahluwalia Saurabh et al. (2020) analyzed how to use blockchain technology for start-up financing, and proposed a model based on the theory of transaction cost economics and the transaction nature of blockchain technology to demonstrate how to use blockchain technology to overcome many problems inherent in start-up financing of enterprises (Ahluwalia, 2020). Feng Bao et al. (2022) takes the platform-type supply chain finance financing business as the research object, analyzes the factors that affect the decision-making of participants, builds a tripartitic evolutionary game model of smes, core enterprises and financial institutions under traditional circumstances and under the drive of blockchain, respectively, and explores the balanced choice of each participant (Feng, 2022). Huo Hong et al. (2022) aiming at the agricultural supply chain composed of e-commerce, farmers and leading enterprises, took into account the bankruptcy risk of

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farmers and the output randomness of agricultural products, respectively built the income model of e-commerce, farmers and leading enterprises under the insurance and risk sharing mode, and proposed the optimal decision of e-commerce, farmers and leading enterprises and the influencing factors of the optimal decision (Huo, 2022). Sun Zhonghe and Xu Xiaoyan et al. (2021) selected 11 risk assessment indicators of agricultural supply chain finance business, built an agricultural supply chain risk assessment model based on GA-BP neural network, and verified the proposed risk assessment model with case analysis (Sun, 2021). Wang Y. (2021) Combined blockchain and fuzzy neural network algorithm, studied the credit risk of SME financing from the perspective of SME financing, built the supply chain financial information module by integrating the financial system with blockchain technology, adopted fuzzy neural network algorithm for financial data processing and risk assessment, and effectively solved and improved the risk handling level of financial enterprises (Wang, 2021). Based on the current development status of agricultural supply chain finance in China, Zheng Yi (2022) analyzed the main models and development difficulties of supply chain finance and proposed innovative strategies of agricultural supply chain finance (Zheng, 2022).

To sum up, domestic and foreign scholars' research on supply chain finance has combined financial technologies such as blockchain, and some literatures have studied the profit distribution and balanced selection of various participants in supply chain finance. It rarely discusses the promotion and promotion of the internal drive of the agricultural supply chain financial model in combination with the characteristics of the agricultural supply chain. This paper uses the research experience of domestic and foreign scholars for reference, relies on the agricultural supply chain financial model innovation and benefit distribution model, solves the problems of loose and difficult management of the agricultural supply chain structure, and relies on the blockchain technology to solve the key problems in the implementation of supply chain finance.

3 METHODS AND ANALYSIS

3.1 Analysis of Key Issues in the Implementation of Agricultural Supply Chain Finance

First, Cause analysis of financing difficulties. The supply chain finance relies on the core enterprise's ability to control goods and adjust sales. For the sake of risk control, the capital end is generally willing to provide financial services only to the core enterprise's upstream and downstream primary suppliers and dealers, which leads to the failure to meet the needs of secondary and tertiary suppliers/dealers with huge financing needs. In addition, bills cannot be separated during the financing process, and the flexibility of use is very limited. Therefore, the main problems in financing are credit multi-level transmission, bill splitting and trust consensus.

Second, the characteristics of supply chain finance require participants to have a very detailed and full understanding of the whole industry chain, and have high requirements on the control ability and technical ability of underlying assets. In order to reduce risks, it is difficult to reduce the operating costs of supply chain finance. In addition, the supply chain financing business lacks a regulatory body in the implementation process. In order to obtain financing, SMEs make unlimited concessions in the discount rate, which makes the overall financing cost of the supply chain rise. Therefore, the problem of expensive financing mainly lies in the consensus of trust, the achievement of risk management and control, and the cooperation of enterprises in the agricultural supply chain.

Third, agriculture itself has a long production input cycle, and there is a serious problem of information islands in the agricultural supply chain system. Pledged goods are stored in third-party logistics companies, and it is difficult to verify the authenticity, quality, status, transaction and other storage information of goods, which increases the difficulty of information audit and lengthens the audit cycle. Therefore, the problem of slow financing is mainly the difficulty of preventing bill fraud and the achievement of the efficiency of bill information review.

Therefore, the key issues of agricultural supply chain financial development can be summarized as trust consensus, bill splitting, credit transmission, risk control, bill cost, slow information review, etc.

3.2 Construction Method of New Model of Agricultural Supply Chain Finance Implanted with Blockchain Technology

3.2.1 Construction of Agricultural Supply Chain Financial Data System

Based on blockchain and big data technology, build a

visual, tamper proof, non replicable and traceable agricultural supply chain financial data platform, and rely on this platform to achieve online data storage and business online operation on the agricultural supply chain., as shown in Figure 1.

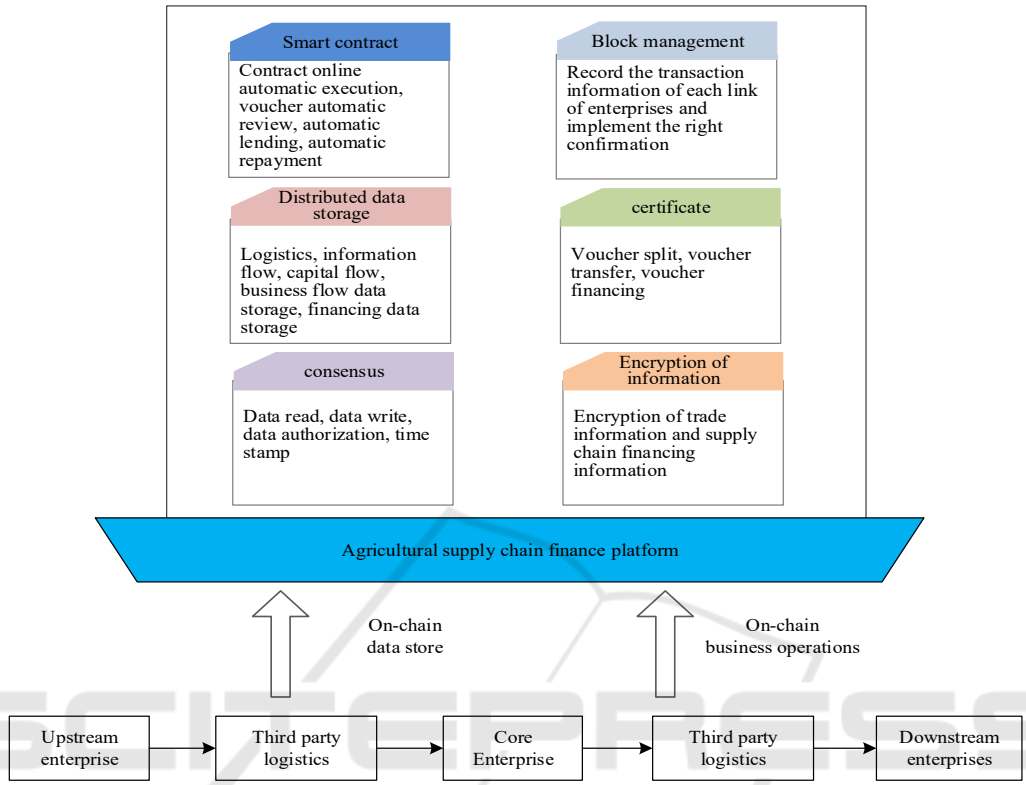

Figure 1: Core module of agricultural supply chain finance platform

Suppliers, core enterprises, distributors, retailers, third-party logistics companies, banks and other financial institutions in the supply chain create blockchain users. Block users record logistics, capital flow, information flow, business flow and other information related to their own business, and upload them to the agricultural supply chain financial platform. These data are recorded synchronously in each enterprise with the occurrence of business in the supply chain, A decentralized database of the whole supply chain process has been formed. Of course, it is not safe to disclose all these information. Therefore, the asymmetric encryption algorithm is used to encrypt the data uploaded by enterprises with public keys, and different users are given different download permissions. When enterprises download the data they need, they use the private key to decrypt it.

3.2.2 Implementation Logic of Trust Consensus

Under the blockchain framework, the upstream and downstream enterprises and financial institutions of the supply chain, as node enterprises, can obtain system data at any time. The decentralized distributed structure can solve the problem of information asymmetry. Node enterprises do not need to trust a single node in a centralized way, and also save a lot of intermediate costs. In addition, due to the tamper proof, non replicable and traceability of blockchain technology, the reliability of transaction information has been improved, thus establishing the trust consensus of all participants in the supply chain.

3.2.3 Implementation Logic of Bill and Transaction Information Fraud Prevention

The ledger distribution feature of the blockchain enables the supply chain system to automatically form data that cannot be tampered with, and these data will be confirmed in real time by the blockchain technology, which not only reduces the delay, but also solves the problem of information audit. The tamper proof timestamp can solve the problem of data tracking and information anti-counterfeiting. In

addition, the data blocks in the blockchain are connected in order and form an tamper proof data chain. Timestamps attach a set of real data that cannot be forged to all transactions, which can effectively prevent bill forgery, information distortion and other problems.

3.2.4 Information Audit Efficiency Improvement

Since the system stores reliable and tamper proof data, as a computer execution language, smart contracts can eliminate all artificial obstacles to the execution of the contract and realize the automatic transfer of capital, goods, claims and other assets under the condition that the set conditions are met. It is mandatory and solves the problem of low efficiency and high cost of labor.

3.2.5 Implementation Logic of Credit Transfer and Bill Disassembly

Under the traditional supply chain finance mode, only enterprises with direct transaction relationship with core enterprises can be supported to finance. The credit of core enterprises cannot be transferred, and the accounts receivable vouchers cannot be disassembled. Under the blockchain structure, the token disassembles the credit of the detachable core enterprises and transfers the credit level by level, so that the upstream and downstream remote enterprises of the supply chain can enjoy the credit guarantee of the core enterprises, expand the financial benefit coverage of the supply chain, and meet the financing needs of all SMEs in the supply chain.

3.3 Basic Principle of “Shapley” Value Method

In the supply chain finance business, core enterprises, agriculture-related smes and financial institutions form an alliance to pursue the effect of 1+1>2. The prerequisite for the long-term, sustainable and stable cooperation of such an alliance is that all parties can obtain their due share of income in the income distribution. In this paper, the benefits of alliance members are distributed based on the "Shapley" value method, which can reflect the contribution degree of each participating enterprise to the overall goal of supply chain finance, and has good rationality and fairness. Specific assumptions are as follows:

Let I be the enterprise set of the cooperative alliance of n participants, expressed as I:{1,2... , n}, participants set S is a subset of the I (S ⊆ I), expressed in V (S) each of the participants set S corresponding revenue function, meet:

$$V(\phi)=0 \\ V(S_1 \cup S_2) \geq V(S_1)+V(S_2), S_1 \cap S_2 = \phi, S_1, S_2 \subseteq I \quad (1)$$

Formula (1) indicates that the revenue of any two disjoint enterprise sets in the case of cooperation is no less than the revenue of non-cooperation. Therefore, when all the participants cooperate, the maximum revenue will be reached, which is denoted as V(I).At this time, X_i is used to represent the income distribution quota obtained by members i of the largest aggregate I from the maximum cooperation income V(I) according to their contribution degree, forming an n-dimensional vector $X=(X_1, X_2,..., X_n)$, which meets the following conditions:

(1) Meet the individual rationality, that is, the income of an enterprise when it joins the alliance and chooses to cooperate must not be less than the income of its own independent operation, otherwise the enterprise will not choose to join, so $X_i \geq V(i)$.

(2) Meet the overall rational condition, that is, the total income obtained by the alliance must be fully distributed, otherwise all member enterprises will not agree to this distribution scheme, so

$$\sum_{i=1}^{n} X_i = V_I, i=1,2,...,n$$

According to the "Shapley" value method, the income distribution amount X_i of participating enterprise i is called the "Shapley" value, which is recorded as $\varphi_i(E)$. The calculation formula is as follows:

$$\varphi_i(E)=\sum_{S \subseteq I} W(|S|)[V(S)-V(S/I)] \\ \text{其中} W(|S|)=\frac{(n-|S|)!(|S|-1)!}{n!} \quad (2)$$

N is the number of all participants in set I, |s| is the number of cooperative enterprises in subset S, V(S) is the overall income of subset S, V (S/I) is the income obtained when member i does not participate in cooperation in subset S, and W(|s|) is the weighting factor.

4 RESULTS

4.1 "1+1+N" Financial Model of Agricultural Supply Chain

The "1+1+N" agricultural supply chain financial model is a new agricultural supply chain financial model operated by one leading enterprise and one

rural cooperative. N refers to small and medium-sized agricultural enterprises, logistics companies, commercial banks, etc. Leading enterprises have market influence and good qualifications, which are suitable for endorsing all links of supply chain financing, and can play a leading and promoting role in the development of supply chain finance; As a special organization, the cooperative has a deep foundation of farmers and financial support from the state. It has natural advantages in the collection of supply chain financial data. Therefore, the rural cooperative is most suitable for the operation of the agricultural supply chain financial data platform, and is responsible for the specific business of the supply chain financial data platform, such as platform building, daily operation, data maintenance, etc. The agricultural supply chain financial platform operated by cooperatives has the objectivity and timeliness of information. The addition of blockchain technology makes the data tamper proof and open, and enables the bill to be disassembled and the transaction efficiency to be improved. In this way, an open platform jointly recognized by enterprises has been formed. All small and medium-sized agricultural enterprises, financial institutions and logistics companies that are interested in participating in the supply chain financial business can register on the platform, Participate in it and make profits respectively. This mode is applicable to most types of agricultural supply chains, and the overall architecture is shown in Figure 2.

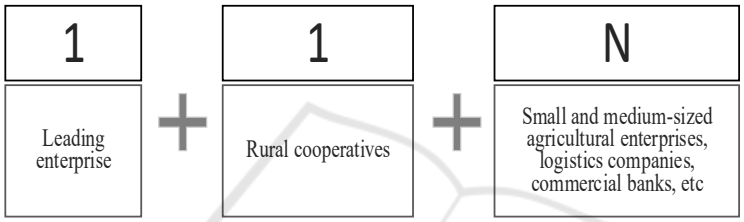

Figure 2: Financial structure of agricultural supply chain.

4.2 Construction of Financial Benefit Distribution Model in Agricultural Supply Chain

The existence of rural cooperatives is to improve the level of farmers' organization, promote the development of agricultural production and increase farmers' income. It is an important window for farmers to talk with the government. The primary purpose of the establishment of cooperatives is not to earn excess profits, and there are national financial subsidies. From the perspective of model construction, cooperatives maintain the platform and do not directly create benefits for the supply chain alliance. According to the nominal representative axiom of the "Shaley" value method, those who have not made contributions to the system should not share the benefits, which is called nominal representatives. Therefore, in combination with the "1+1+N" agricultural supply chain financial model, the interest distribution among financing enterprises (i.e. agricultural SMEs), commercial banks and leading enterprises is mainly considered.

Suppose the financing enterprise is X, the commercial bank is Y, and the leading enterprise is Z, then I={X, Y, Z}, the cooperation between X and Y is XY, the cooperation between X and Z is XZ, the cooperation between Y and Z is YZ, and the supply chain alliance formed by X, Y, and Z is XYZ. Set the annual profits of financing enterprises, commercial banks and leading enterprises when they operate alone and do not participate in cooperation as x, y and z respectively, and the expected income of X and Y cooperation is a; the expected income of X and Z cooperation is b; the expected income of Y and Z cooperation is c. If X Y and Z cooperate to form a supply chain alliance, and the expected income is d. According to formula (2), calculate the benefit distribution table of each participating enterprise, as shown in Table 1:

Table 1: $\varphi_i(E)$ value solution table

S_X	V(S)	V(S/X)	V(S)-V(S/X)	$W(\|S\|)$	$W(\|S\|)[V(S)-V(S/I)]$
X	x	0	x	1/3	x/3
XY	a	y	a-y	1/6	(a-y) /6
XZ	b	z	b-z	1/6	(b-z) /6
XYZ	d	c	d-c	1/3	(d-c) /3

Therefore, the profit distribution of financing enterprise X is:

$$\varphi_i(E) = \sum_{S \subseteq I} W(|S|)[V(S) - V(S/I)]$$
$$= x/3 + (a - y)/6 + (b - z)/6 + (d - c)/3$$
$$= (-x - y + 2z - 2a + b + c + 2d)/6$$

Similarly, the profit distribution of commercial banks is (- x+2y-z+a-2b+c+2d)/6, and that of leading enterprises is (- x-y+2z-2a+b+c+2d)/6.

5 DISCUSSION

When studying the benefits of each participant in the supply chain, the "Shapley" value method mainly distributes the total benefits of the supply chain according to the contribution of each participant to the supply chain. In the actual supply chain financial business, according to the different risks undertaken by the participating enterprises, on the basis of the benefit distribution model, the participating enterprises with large risks can allocate relatively more benefits, so as to urge the supply chain related enterprises to actively participate in the supply chain financial business. In future research, risk correction factors can be introduced to modify the Shapley value, thus forming an improved supply chain financial benefit allocation model.

6 CONCLUSIONS

This research enriches the relevant theories of blockchain enabled supply chain finance. Through the application of blockchain, the risk of "1+1+N" agricultural supply chain financial model has been greatly reduced. From the perspective of commercial banks, the problems of trust consensus, risk management and control, and bill cost of all participating enterprises have been well solved; For financing enterprises, problems such as bill splitting, credit transmission and slow information review have been solved; For leading enterprises, while helping SMEs solve the capital problem, it has improved the management and control ability of the agricultural supply chain and the stickiness between enterprises, thus boosting the development of the agricultural industry chain.

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