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Research Article

Financing the Three-Tier Supply Chain: Advance Payment vs. Blockchain-Enabled Financing Mode

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Supply chain finance has shown remarkable results in alleviating the financial constraints of small and medium-sized enterprises. However, most studies have concentrated on the two-tier supply chain while ignoring the financing issues of the deep-tier supply chain. This study introduced the blockchain-enabled financing mode now utilized in the manufacturing industry and constructed a three-tier agricultural supply chain considering the farmer's financial constraints. The main contributions of this article are (1) presenting the blockchain-enabled financing mode in the three-tier agricultural supply chain and (2) investigating supply chain decision-making in the three-tier supply chain when the tier-2 supplier is financially constrained, comparing advance payment and the blockchain-enabled financing mode. Relevant parameter estimations were realized using the data of the last ten years, and numerical analyses were conducted. The results show that when the farmer's bank's financing capability exceeds the acquirer's, the farmer is motivated to select the blockchain-enabled financing mode. However, a win-win situation among the three-tier supply chain is only achievable when the transmission-fee rate falls within a particular range. In addition, if government agencies wish to promote blockchain technology by subsidizing blockchain-enabled financing, they might support the farmer in obtaining a bank loan at a cheaper interest rate. All members of the supply chain would benefit from this.

1. Introduction

Supply chain finance relies on the credit support of core enterprises to mitigate the risk resulting from information asymmetry [1]. It includes various financing options such as order financing and advance payment [2, 3]. They address the problem of "difficult and expensive financing" for new agricultural business entities in China by enhancing the bank's ability to finance capital-constrained subjects. However, approximately 20% of small and medium-sized enterprises (SMEs) can acquire loans (https://www.supplychainbrain.com/articles/32605-supply-chain-financing-for-us-mid-market-will-benefit-economy). And only financially constrained SMEs having a direct transactional relationship with the core enterprises in a multilevel supply chain are eligible for help. In the three-tier and even n-tier supply chains, most SMEs do not have a direct relationship with the core enterprise. According to Dong, it is a visibility barrier in *the deep-tier supply chain* [4]. Farmers in the agricultural supply chain are typically distant from the core enterprises in the deep-tier supply chain, making it difficult for them to benefit from traditional supply chain finance.

Blockchain technology offers novel solutions to the issues above [5–8]. In recent years, the government has provided numerous subsidies to encourage firms' adoption of blockchain technology. Local government departments (e.g., Kunshan, Jiangsu Province) are increasingly collaborating with core enterprises to overcome the visibility barrier in the deep-tiers supply chain. For instance, the "Simple Hub" product from TCL Group enables core enterprises to issue electronic debt flow certifications (also known as gold sheets) within the system. Those possessing gold sheets can apply for financing through the platform's banking institutions. Through the gold bill, the bank financing capacity of noncore enterprises is equivalent to that of core enterprises. In addition, the gold sheets can be totally or partially transferred between $1 - N$ level suppliers to suit the financing requirements of end enterprises. This mode of financing broadens the financing channels available to capital-constrained upstream and downstream enterprises. Similarly, there are innovative financial products such as "E Pay Easy" and "Credit List." For convenience, we use the name "blockchain-enabled financing mode (subsequently called B mode)" from Dong et al. [4]. By adopting the B mode, the capital-constrained subject in our study can receive gold sheets from the core business and subsequently obtain a bank loan. However, the new mode of financing is one of many alternatives available to farmers. Farmers can also employ the traditional advance payment (called A mode) and obtain direct loans from downstream firms to tackle the problem of insufficient production capital. Therefore, it is vital to investigate how farmers select a suitable mode of financing in the multitier supply chain system.

Kouvelis and Zhao contended that retailers will not pick a bank loan if effectively constructed trade credit contracts are given within the supplier early payment discount schemes [9]. In contrast, Jing and Seidmann claim that trade credit is preferable to a bank loan only when manufacturing costs are relatively low, mitigating the double marginal utility more effectively [10]. As previously noted, these studies belong to retailer financing, whereas farmers belong to suppliers. Tang et al. investigated two methods of financing suppliers: purchase order financing and buyer-direct financing [11]. They discovered that the informational advantage of the manufacturer makes buyer-direct financing the preferred method for contracting with efficient suppliers. According to Kouvelis and Xu, retailers should only offer reverse factoring to suppliers with low returns on cash investment that exceed a particular threshold [12]. However, little attention has been paid to the issue of financing the supplier in the deep-tier supply chain. Presumably, all supply chain members can increase their profits by adopting blockchain technology for finance. The value is emphasized when improvements in blockchain technology facilitate supply chain transparency and blockchain-powered smart contracts enhance the flexibility to automate loan transactions [13].

In light of those above, we provided blockchain-enabled financing to the three-tier agricultural supply chain, which includes the farmer (tier-2 supplier), the acquirer (tier-1 supplier), and the core enterprise. However, the mode is unexplored in the literature. In three-tier supply chain finance, the effect of the transmission-fee rate, which was implemented to defend the interests of tier-1 suppliers, still needs to be discovered. Comparing advance payment and blockchain-enabled financing modes, this article investigates the following concerns: (1) What are the optimal decisions for each party given the two financing modes? (2) How do the transmission-fee and interest rates influence the optimal decisions of the three-tier supply chain members? (3) How would transmission-fee and interest rates influence the parties' payoffs?

In answering the proposed research questions, we first describe the advance payment (A mode) and blockchain-enabled financing (B mode) financing operations. The decision of the financing mode by farmers is typically highly influenced by the financing cost. Consequently, we devised two distinct parameters for the two financing modes based on real-world financing scenarios and established standards from the literature. Using a comparison of operational decisions, we assess the respective values of A and B finance modes. The results demonstrate that each participant in the supply chain can select the mode of financing that best meets their demands in light of the applicable conditions. We calibrated the model utilizing the R programming language with data from the websites of the Chinese Ministry of Agriculture and Rural Development and the National Bureau of Statistics for the previous decade. We present the outcomes of numerical examples that further investigate the impact of critical parameters on the two financing methods. Therefore, the article's primary contribution is as follows:

(1) Presenting a blockchain-enabled financing mode in the three-tier agricultural supply chain.

(2) Investigating supply chain decision-making in a three-tier supply chain with a financially constrained tier-2 supplier and comparing the difference between advance payment and blockchain-enabled financing mode.

The remaining sections are organized as follows. Section 2 contains our literature review. Section 3 outlines the model structure, analyses the two financing modes, and compares the optimal decisions. Section 4 provides the numerical analysis and illustrates the influence of the crucial variables. Section 5 provides managerial insights and implications. Finally, Section 6 concludes with our results and suggestions for future research. The proofs of propositions, data sources, and model calibration results are relegated to Appendix.

2. Literature Review

2.1. Financing for Upstream Supplier. The literature related to this study is about financing for the upstream supplier. Standard financing modes include purchase order finance, advance payment, and bank loans. Ding and Wan for example, compared the two modes of advance payments from manufacturers versus a bank loan and discovered that suppliers pick just one of the two sources of financing, not both [14]. In addition, manufacturers are always eager to finance their suppliers' production with advance payments. Huang provided recommendations on the discount rate and buyer's payment timeline of the balance due for supplier disruption risk [15]. Deng et al. compared two financing modes: advance payment and a bank loan [16]. In our opinion, the advance payment also enables buyers to negotiate lower purchase prices through lower discount rates. The influence of loss aversion was of more concern to Yan et al. than the discount rate [17]. They found that the increased loss aversion of the retailer in the advance payment mode prompts it to lower the wholesale price. And greater loss aversion reduces output in the investment mode. In addition, Zhan et al. evaluated the preferences of supply chain members for advance payment against reverse factoring, taking into account the sustainability and effectiveness of the supply chain [18]. All participants favour reverse factoring, according to their findings. Moreover, Kouvelis and Zhao analysed the impact of credit ratings on supply chain operations and financial decisions while considering the financial constraints of both upstream and downstream enterprises [19]. They identified a threshold value above which the supplier offers trade credit with zero percent interest and the retailer uses exclusively trade credit. Otherwise, the supplier sets an interest rate that encourages the retailer to combine trade credit with a bank loan.

Unlike the previous articles, this article builds a three-tier agricultural supply chain. We introduced a novel blockchain-enabled financing mode to resolve this three-tier supply chain upstream capital constraints issue.

2.2. Blockchain-Enabled Financing Mode. The usage of blockchain technology in supply chain finance is growing [1, 20–23]. For example, Zheng et al. studied the applicability of smart contracts in supply chain factoring [24]. Chod et al. demonstrated that blockchain technology could provide enterprises access to advantageous financing terms at reduced signalling costs [25]. Cao et al. evaluated the role of blockchain platforms in the context of limited supplier capital [26]. They discovered that the engagement of blockchain platforms could increase the supply chain's output and total surplus. The development of a blockchain platform will always favour buyers. In most cases, suppliers can profit. Liu et al. investigated the blockchain platform finance [27]. Wang et al. focused on applying blockchain technology in trade credit [28]. However, they considered a three-tier supply chain with a capital-constrained retailer.

Only Dong et al. have explored blockchain-enabled deep-tier supply chain finance with a capital-constrained supplier, as far as we are known [4]. They demonstrated that blockchain's enhanced transparency might aid firms in making informed financing decisions for their supply chain. However, blockchain-enabled delegate financing can only raise expenditures in risk mitigation and benefit all supply chain participants when secondary suppliers are severely cash-constrained. This delegate financing allows a tier-1 supplier to borrow funds to pay a tier-2 supplier the required amount. In contrast to their delegated financing, we employ a distinct and universal mode (such as the TCL example) that enables tier-1 suppliers to split their accounts receivable and use those receivables to pay tier-2 suppliers.

2.3. Research Gap. As mentioned above, the research gap observed in the studies is related to the lack of a financing mode for tier-2 supplier financial constraints. Consequently, the blockchain-enabled finance mode has been established, and the implementation approach differs from that described by Dong et al. [4]. We share the same name with them. A lack of understanding of the impact of blockchain-enabled financing mode is a different research gap. Consequently, advance payment is also utilized in the three-tier supply chain and compared to optimal decisions and profit under the blockchain-enabled financing mode. In Table 1, research literature from the past is categorized.

3. Problem Statement

Typically, an agricultural supply chain comprises of a core enterprise and numerous upstream and downstream SMEs. This study focuses on the financing and operations of the core enterprise's tier-2 supplier. Therefore, we established an agricultural supply chain with a single core enterprise, acquirer, and capital-constrained upstream farmer. The core enterprise determines its purchase price. The acquirer then determines the acquisition price. Ultimately, the farmer chooses the planting area (e.g., 10 ha of wheat).

3.1. Notation List and Assumptions. Parameters and decision variables are defined in Table 2.

Two financing modes are considered to solve the capital constraint problem of the farmer: the advance payment (A mode) and the blockchain-enabled financing mode (B mode), denoted by superscripts A and B, respectively.

When the farmer adopts the A mode, the acquirer provides an advance payment for the farmer's production activity. As shown in Figure 1, the process between the three parties in the agricultural supply chain under the advance payment is as follows. (1) The core enterprise orders agricultural products from the acquirer at a specific price. (2) The acquirer buys agricultural products from the farmer at a predetermined price. In addition, a portion of the payment is made in advance, depending on a set discount rate to satisfy the farmer's production funding needs. (3) The farmer determines the area for planting. During harvest, it provides the acquirer with agricultural products while the acquirer pays the acquisition price. (4) The acquirer supplies the core enterprise with agricultural products. (5) The core enterprise packages and sells agricultural products to consumers after processing and packaging them.

When the farmer adopts the B mode (see Figure 2), the following sequence of events occurs between the three parties in the agricultural supply chain: (1) The core enterprise places an order with the acquirer for agricultural products at a specified price. (2) The acquirer purchases agricultural products from the farmer at a predetermined price and provides the farmer with an electronic flow certificate for a portion of the core enterprise's receivables. This certificate can be used as collateral to get a bank loan for the farmer. (3) The farmer can use that certificate as a collateral to obtain a bank loan. (4) With the assistance of a bank loan, the farmer chooses the planting area in accordance with the acquirer's buying price. The acquirer receives the goods during the harvest season. (5) The acquisition supplies the core enterprise with agricultural products. (6) The core enterprise purchases all the agricultural products from the acquirer, processes, packages them, and then sells them to the market consumers.

Therefore, the assumptions are as follows:

Table 1: Literature categorized of supply chain finance.

Reference	Supply chain	Financial constraint party	Financing mode
Kouvelis and Zhao [9]	Two tiers	Retailer	Trade credit and bank loan
Jing and Seidmann [10]	Two tiers	Retailer	Trade credit and bank loan
Tang et al. [11]	Two tiers	Supplier	Order financing and buyer-direct financing
Kouvelis and Xu [12]	Two tiers	Supplier	Reverse factoring
Ding and Wan [14]	Two tiers	Supplier	Advance payment and bank loan
Huang [15]	Two tiers	Supplier	Advance payment
Deng et al. [16]	Two tiers	Supplier	Advance payment and bank loan
Yan et al. [17]	Two tiers	Supplier	Advance payment
Ding and Wan [14]	Two tiers	Supplier	Advance payment and reverse factoring
Kouvelis and Zhao [19]	Two tiers	Supplier and retailer	Trade credit and bank loan
Liu et al. [27]	Three tiers	Retailer	Blockchain platform finance
Wang et al. [28]	Three tiers	Retailer	Trade credit using blockchain
Dong et al. [4]	Three tiers	Tier-2 supplier	Blockchain-enabled financing mode
This research	Three tiers	Tier-2 supplier	Advance payment and blockchain-enabled financing mode

Table 2: Notation list.

Variables	Description
Parameters	
p	Market price
a	Choke price
b	The price sensitivity of inverse demand function
Q	The output of agricultural products
μ	Expectation of output coefficient
q	The planting area
c_1	Unit input cost of the farmer
c	The output effort cost of the farmer
π_F	The profit of the farmer
π_S	The profit of the acquirer
π_R	The profit of the core enterprise
r_A	The discount rate about advance payment
r_E	The risk-free rate of the acquirer
r_B	Bank loan interest rate
r_1	Transmission-fee rate for the electronic certificate in B mode
Decision variables	
q	The farmer's planting area
ω	The price at which the acquirer buys the product from the farmer
ψ	The price at which the core enterprise buys the product from the acquirer

(1) In this supply chain, we assumed that both the core enterprise and the acquirer have adequate financial resources. In addition, the acquirer possesses adequate electronic flow certificates of accounts receivable (from the core enterprise). Only the farmer faces the challenge of limited capital.

(2) Since the actual output of agricultural products is subject to uncertainty, let the random output coefficient be x, i.e., the quantity of agricultural output obtained per unit of input, where the mathematical expectation is μ, e.g., 12000 kg/ha. For convenience, assume the output $Q = \mu q$, where q means the planting area.

(3) Market sales are considered to match the number of agricultural products purchased by the core firm, excluding shortage losses and unsold items' residual value. Without loss of generality, considering that the market price and sales volume of processed agricultural products obey the relationship $p = a - \mathrm{b}Q$, where $a\,(>0)$ denotes the choke price; consumers will not buy the commodity when the market price exceeds the choke price. The parameter b indicates the price sensitivity of the inverse demand function.

(4) The farmer decides the planting area based on the purchase price and financing cost, where the quadratic production cost function $C(q) = c_1 q + cq^2$ is commonly used to describe the diseconomies of scale [26, 29, 30], c_1 representing the input cost coefficient, $c_1 q$ representing the cost of cultivating arable land for inputs such as seeds, fertilizers, and pesticides, and c reflects the coefficient of output effort cost. A bigger output effort input indicates inefficiency. To simplify the computation without compromising its generality, let $c_1 = 0$, $c > 0$.

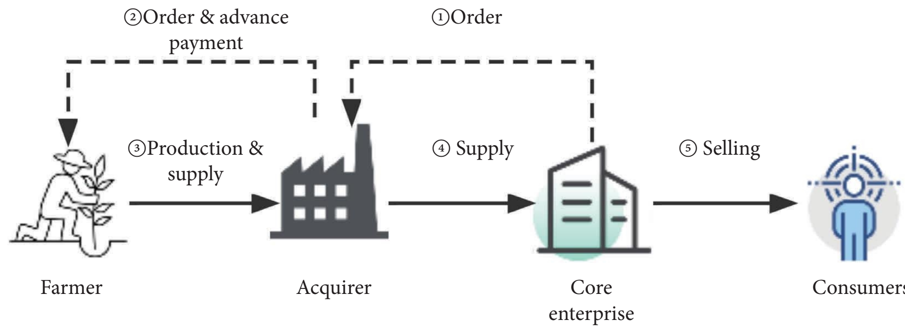

Figure 1: A mode process.

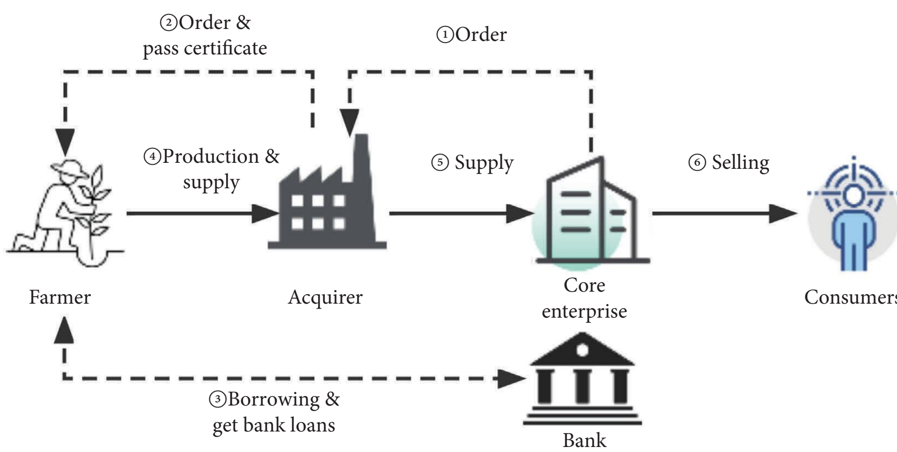

Figure 2: B mode process.

(5) The profit of each party is represented by π_i, $i = F, S, R$, and the subscripts F, S, and R, respectively, represent the farmer, the acquirer, and the core enterprise.

(6) We assume that the acquirer's discount rate for advance payment is r_A and the risk-free rate is r_E, which can be viewed as the acquirer's bank financing capability and $r_A > r_E$.

(7) We assume that the interest rate on the farmer's bank loan in B mode is r_B. It can be considered the farmer's bank financing capacity under the B mode. The farmer needs to pay the fees to the acquirer at transmission-fee rate r_1. Assuming $r_B + r_1 < r_A$, otherwise it would not be profitable for the farmer to adopt the B mode.

(8) We also assumed that the cost of supply chain investment in blockchain technology is zero, and we disregarded the cost of using the blockchain platform. We examined the matter of the farmer's choice of financing mode in terms of the loan cost required to execute various financing modes. Because on the one hand, local government departments in pilot zones typically finance new technology inputs to decrease or even cover the cost of digitization. On the other hand, our research focuses on the costs and benefits that result from applying the financing mode. Considering the fact that technological inputs will become sunk costs over time, eliminating sunk costs can better account for the essential differences between the two financing modes by excluding unnecessary impacts.

3.2. Solution Approaches

3.2.1. Advance Payment (A Mode). Advance payment is the traditional mode of financing that helps reduce the farmer's financial constraints. At this time, each member's profit functions are as follows:

$$\begin{aligned}\pi_F^A &= \omega Q - cq^2(1 + r_A),\\ \pi_S^A &= (\psi - \omega)Q + cq^2(r_A - r_E),\\ \pi_R^A &= (p - \psi)Q.\end{aligned} \tag{1}$$

The decision function of the farmer is as follows:

$$\max \pi_F^A = \max\left(\omega Q - cq^2(1 + r_A)\right). \tag{2}$$

Solving the above equation, the optimal planting area for production can be determined as follows:

$$q = \frac{\mu\omega}{2c(1 + r_A)}. \tag{3}$$

The acquirer's decision function is as follows:

$$\max \pi_S^A(q) = \max\left((\psi - \omega)Q - cq^2(r_A - r_E)\right). \tag{4}$$

Solving the above equation, we can obtain the optimal purchase price as follows:

$$\omega = \frac{(1+r_A)\psi}{2+r_A+r_E}. \tag{5}$$

Substituting the values of q and ω into the core firm profit function, the core firm optimal decision function is as follows:

$$\max \pi_R^A(q,\omega) = \max((p-\psi)Q). \tag{6}$$

Solving the above equation, we can obtain the optimal purchase price as follows:

$$\psi^* = \frac{ac(2+r_A+r_E)}{2c(2+r_A+r_E)+b\mu^2}. \tag{7}$$

The equilibrium solution in the A mode is shown as follows:

$$q_A^* = \frac{a\mu}{4c(2+r_A+r_E)+2b\mu^2}, \tag{8}$$

$$\omega_A^* = \frac{ac(1+r_A)}{2c(2+r_A+r_E)+b\mu^2}, \tag{9}$$

$$\psi_A^* = \frac{ac(2+r_A+r_E)}{2c(2+r_A+r_E)+b\mu^2}, \tag{10}$$

$$\pi_F^{A*} = \frac{a^2\mu^2(1+r_A)c}{4\left(2c(2+r_A+r_E)+b\mu^2\right)^2}, \tag{11}$$

$$\pi_S^{A*} = \frac{a^2\mu^2(2+r_A+r_E)c}{4\left(2c(2+r_A+r_E)+b\mu^2\right)^2}, \tag{12}$$

$$\pi_R^{A*} = \frac{a^2\mu^2}{4\left(2c(2+r_A+r_E)+b\mu^2\right)}. \tag{13}$$

3.2.2. Blockchain-Enabled Financing Mode (B Mode). The blockchain-enabled financing mode has been used to address the financial constraints of the deep-tier supply chain [4, 27]. At this point, the profit function of each member is as follows:

$$\begin{aligned}
\pi_F^B &= \omega Q - cq^2(1+r_B+r_1),\\
\pi_S^B &= (\psi-\omega)Q + cq^2 r_1,\\
\pi_R^B &= (p-\psi)Q.
\end{aligned} \tag{14}$$

The farmer's decision function is shown as follows:

$$\max \pi_F^B = \max\left(\omega Q - cq^2(1+r_B+r_1)\right). \tag{15}$$

Solving equation (15), we can obtain the optimal area of arable land for production as follows:

$$q = \frac{\mu\omega}{2c(1+r_B+r_1)}. \tag{16}$$

Substituting q into the acquirer's profit function, the acquirer's optimal decision function is as follows:

$$\max \pi_S^B(q) = \max\left((\psi-\omega)Q + cq^2 r_1\right). \tag{17}$$

Solving the above equation, we can obtain the optimal purchase price as follows:

$$\omega = \frac{\psi(1+r_B+r_1)}{2(1+r_B)+r_1}. \tag{18}$$

Substituting the values of q and ω into the core firm profit function, the core firm optimal decision function is as follows:

$$\max \pi_R^B(q,\omega) = \max((p-\psi)Q). \tag{19}$$

Solving equation (19), we can obtain the optimal purchase price as follows:

$$\psi^* = \frac{ac(2(1+r_B)+r_1)}{4c(1+r_B)+2cr_1+b\mu^2}. \tag{20}$$

The equilibrium solution in the B mode is shown as follows:

$$q_B^* = \frac{a\mu}{2\left(4c(1+r_B)+2cr_1+b\mu^2\right)}, \tag{21}$$

$$\omega_B^* = \frac{ac(1+r_B+r_1)}{4c(1+r_B)+2cr_1+b\mu^2}, \tag{22}$$

$$\psi_B^* = \frac{ac(2(1+r_B)+r_1)}{4c(1+r_B)+2cr_1+b\mu^2}, \tag{23}$$

$$\pi_F^{B*} = \frac{a^2\mu^2c(1+r_B+r_1)}{4\left(4c(1+r_B)+2cr_1+b\mu^2\right)^2}, \tag{24}$$

$$\pi_S^{B*} = \frac{a^2\mu^2c(2(1+r_B)+r_1)}{4\left(4c(1+r_B)+2cr_1+b\mu^2\right)^2}, \tag{25}$$

$$\pi_R^{B*} = \frac{a^2\mu^2}{4\left(4c(1+r_B)+2cr_1+b\mu^2\right)}. \tag{26}$$

3.3. Comparison of Advance Payment and Blockchain-Enabled Financing Mode

3.3.1. Comparison of Purchase Price. We derived the following propositions by comparing the acquirer and the core enterprise purchase price between advance payment and blockchain-enabled financing modes.

Proposition 1. *(1) When $r_B < r_E$, there is a threshold value $\hat{r}_0$. If $r_1 > \hat{r}_0$, we have $\omega_B^* > \omega_A^*$. If $r_1 < \hat{r}_0$, we have $\omega_B^* < \omega_A^*$. If $r_1 = \hat{r}_0$, we have $\omega_B^* = \omega_A^*$. (2) When $r_B \geq r_E$, $\omega_B^* < \omega_A^*$ constantly holds. The expression of $\hat{r}_0$ is as follows:*

$$\hat{r}_0 = \frac{(r_A - r_B)b\mu^2 + 2c(r_A - r_E)(1 + r_B)}{b\mu^2 + 2c + 2cr_E}. \tag{27}$$

See Appendix A for a detailed description of the proof procedure and the proofs of the following propositions.

Proposition 1 states that: (1) when the acquirer offers a higher transmission-fee rate, the acquirer also increases the acquisition price. The higher the transmission-fee rate, the greater the acquirer's transmission revenue. The acquirer must raise the acquisition price to encourage the farmer to cultivate a larger area. (2) If the farmer's bank financing ability remains insufficient after adopting B mode (i.e., $r_B \geq r_E$), the purchase price of B mode is always lower than that of A mode, regardless of the transmission-fee rate. That is because the transmission revenue of the acquirer in B mode is always lower than the interest revenue in A mode (i.e., $cq^2(r_A - r_E) > cq^2 r_1$) when the farmer's area under cultivation is given. The acquirer in B mode will seek a reduced acquisition price to offset this income loss.

Proposition 2. *(1) When $r_B \leq r_E$, $\psi_B^* < \psi_A^*$ constantly holds. (2) When $r_B > r_E$, there is a threshold value $\hat{r}_1$. If $r_1 > \hat{r}_1$, we have $\psi_B^* > \psi_A^*$. If $r_1 < \hat{r}_1$, we have $\psi_B^* < \psi_A^*$. If $r_1 = \hat{r}_1$, we have $\psi_B^* = \psi_A^*$. The expression of $\hat{r}_1$ is as follows.*

$$\hat{r}_1 = r_A + r_E - 2r_B. \tag{28}$$

Proposition 2 shows that (1) the purchase price of core enterprises under B mode is less if the farmer's bank financing ability is greater after adopting B mode (i.e., $r_B \leq r_E$) because the market for agricultural products is characterized by great volume and low prices (see Proposition 3 (1)). To increase revenue, the core enterprise will seek to reduce the buying price. (2) If the farmer's bank financing ability remains insufficient after adopting the B mode (i.e., $r_B > r_E$), the core enterprise in the B mode will demand a lower purchase price only if the acquirer offers a lower transmission-fee rate. For the same reason as above, see Proposition 3 (2) for details.

3.3.2. Comparison of Expected Production Volumes. We derived the following proposition by comparing the farmer's expected production volumes between advance payment and blockchain-enabled finance modes.

Proposition 3. *(1) When $r_B \leq r_E$, $Q_B^* > Q_A^*$ constantly holds. (2) When $r_B > r_E$, there is a threshold value $\hat{r}_2$. If $r_1 > \hat{r}_2$, we have $Q_B^* < Q_A^*$. If $r_1 < \hat{r}_2$, we have $Q_B^* > Q_A^*$. If $r_1 = \hat{r}_2$, we have $Q_B^* = Q_A^*$. The expression of $\hat{r}_2$ is as follows:*

$$\hat{r}_2 = \hat{r}_1 = r_A + r_E - 2r_B. \tag{29}$$

Proposition 3 states that (1) if the farmer's bank financing ability is greater in the B mode (i.e., $r_B \leq r_E$), the farmer will always decide to plant more crops in the B mode because the farmer's production costs are lower in B mode. And even if the transmission-fee rate is high, the acquirer will encourage the farmer to increase the planting area by raising the purchase price. (2) If the farmer's bank financing ability remains insufficient after adopting B mode (i.e., $r_B \geq r_E$), the planting area under B mode is smaller than under A mode when the transmission-fee rate is high. Because the acquirer's purchase price is also lower at this time, the farmer cannot be encouraged to increase the planting area (see Proposition 1 for details).

3.3.3. Comparison of Profit. We obtained the following propositions by comparing the profit of the farmer, the acquirer, and the core enterprise between the advance payment and blockchain-enabled financing modes.

Proposition 4. *(1) When $r_B > (r_A + r_E - r_1)/2$, $\pi_F^{B*} < \pi_F^{A*}$ constantly holds. (2) When $r_B < (r_A + r_E - r_1)/2$, there are two threshold values $\hat{r}_3$ and $\hat{r}_4$. If $\hat{r}_3 < r_1 < \hat{r}_4$, we have $\pi_F^{B*} > \pi_F^{A*}$.*

The expressions of $\hat{r}_3$ and $\hat{r}_4$ are as follows:

$$\hat{r}_3 = \frac{M^2 - 4(1 + r_A)cN - \Delta}{8(1 + r_A)c^2},$$
$$\hat{r}_4 = \frac{M^2 - 4(1 + r_A)cN + \Delta}{8(1 + r_A)c^2}, \tag{30}$$

in which $M = b\mu^2 + 2c(2 + r_A + r_E)$,

$$N = b\mu^2 + 4c(1 + r_B), \text{and}$$
$$\Delta = M\sqrt{M^2 - 8c(1 + r_A)(b\mu^2 + 2c(1 + r_B))}. \tag{31}$$

Proposition 4 shows that (1) if the farmer's bank financing ability remains insufficient, the farmer will always choose A mode to maximize profits, regardless of the transmission-fee rate. In contrast, after selecting B mode, the acquirer's purchase price is lower, resulting in a smaller planting area for the farmer, which is not favourable to increasing the farmer's profit. (2) It shows that the transmission-fee rate only increases the farmer's profit within a certain range when B mode is selected. A low transmission-fee rate does not increase the farmer's profit because the acquirer will set a lower buying price when the rate is low. A costly transmission fee will force the farmer to undertake high capital costs, hence lowering the farmer's profit.

Proposition 5. *If $r_1 < \hat{r}_5$, we have $\pi_S^{B*} > \pi_S^{A*}$. The expression of $\hat{r}_5$ is as follows:*

$$\hat{r}_5 = r_A + r_E - 2r_B = \hat{r}_2 = \hat{r}_1. \tag{32}$$

Proposition 6. *If $r_1 < \hat{r}_6$, we have $\pi_R^{B*} > \pi_R^{A*}$. The expression of $\hat{r}_6$ is as follows:*

$$\hat{r}_6 = r_A + r_E - 2r_B = \hat{r}_5 = \hat{r}_2 = \hat{r}_1. \tag{33}$$

When the farmer selects the B mode, and the acquirer offers a low transmission-fee rate, the acquirer and the core firm can increase their earnings, as illustrated by Propositions 5 and 6. The reason is that a low transmission-fee rate encourages the farmer to increase the planting area, which will increase the profits of the downstream firms.

Corollary 1. *If $\hat{r}_3 < r_1 < \hat{r}_6$, the farmer, acquirer, and core enterprise can achieve a win-win situation for all three parties.*

The inference result implies that, when selecting B mode, the acquirer can set a suitable transmission-fee rate to ensure that all participants of the supply chain benefit. Not only does this raise their profits, but it also strengthens the cooperative relationship amongst supply chain partners.

3.4. Results and Discussion. In order to tackle the financial constraint problem of the farmer in a three-tier agricultural supply chain, we first created game models of two financing modes based on the relevant assumptions and variables. Next, the optimal decisions under two financing options, including the farmer's planting area, the acquirer's purchase price, and the core enterprise's purchase price, are produced using the inverse induction method. Finally, we evaluated the differences in optimal decisions and profits between the two financing modes from a theoretical perspective. On the one hand, the relationship between r_B and r_E directly affects whether the two financing mode decisions are equivalent. On the other hand, the analysis also reveals that the transmission-fee rate r_1 is somewhat moderating since it can further reduce or increase the farmer's actual financing cost. The good range of r_1 can result in a win-win situation for all three partners in the three-tier supply chain, especially when comparing profits. Although studies have been undertaken to illustrate the usefulness of the new method [4, 27], our results show that there are constraints in motivating the supply chain to accept the new financing mode. Sometimes, the traditional financing mode may be better instead. These analyses also lay the foundation for the subsequent numerical analysis.

4. Numerical Analysis

4.1. Model Calibration. This section focuses on the effects of key parameters on the three-tier agricultural supply chain. To improve the validity and accuracy of simulation findings, we obtained data from the websites of the Chinese Ministry of Agriculture and Rural Development and the National Bureau of Statistics to calibrate models. We used the national average yield and acreage statistics for soybean and wheat from 2011 to 2019 to calculate their median output coefficients: 3626.913 kg/ha and 10785.239 kg/ha, respectively.

Similar to Alizamir et al. [31], we constructed the adjusted market price using the consumer price index for residential prices to eliminate the effect of inflation. And we also obtained the adjusted agricultural output data with the number of townships in the country to eliminate the substantial disparities in scale between the data sets. Furthermore, using adjusted market prices as the dependent variable and adjusted output as the independent variable, we estimated the values of a, b by a linear regression equation. Regarding the quadratic term coefficients, we gathered national data on multiple expenses of wheat and soybeans for 2016–2018, including explicit and implicit costs, with reference to Alizamir's study. We substituted the difficult-to-record effort costs in the quadratic production cost function with implicit costs (such as discounted rent for self-camping and discounted wage for household labour). To get the value of the quadratic coefficient, let the overall cost equal the sum of the quadratic costs. We also used three years of data to get the average quadratic term coefficients as simulation parameters. Table 3 demonstrates the specific estimation results. Appendix B provides more information on the data. Given the greater fit and significance found for the soybean data, which can more accurately represent the actual scenario, the estimated results for the soybean data were used as the simulation parameters.

4.2. The Impact of Important Parameters on the Supply Chain

4.2.1. Advance Payment. In the context of the advance payment, the market price is $p_A = 7.343 - 0.0316q_A^*$. Considering the reality, assign the parameters as follows: $r_A \in [0.04, 0.12]$ and $r_E \in [0, 0.06]$. In Table 4, we set $r_E = 0.04$ and show the impact of r_A changes on each supply chain member's decision variables and profits.

Based on Table 4, the result shows that as r_A increases, the farmer's planting area, the acquirer, and core enterprise profits will decrease. However, the farmer's profit, the acquirer, and core enterprise purchase prices will increase.

Similarly, we set $r_A = 0.12$ and show impact of r_E changes in Table 5. The result shows that as r_E increases, only the core enterprise purchase price will increase and other decision variables with all supply chain members profits will decrease.

4.2.2. Blockchain-Enabled Financing Mode. In the context of the blockchain-enabled financing mode, the market price is $p_B = 7.343 - 0.0316q_B^*$. Considering the reality, assign the parameters as follows: $r_1 \in [0, 0.08]$ and $r_B \in [0, 0.10]$. In Table 6, we set $r_B = 0.10$ and show impact of r_1 changes on each supply chain member's decision variables and profits.

Based on Table 6, the result shows that as r_1 increases, the farmer's planting area, the acquirer, and core enterprise profits will decrease. However, the farmer's profit, the acquirer, and core enterprise purchase prices will increase.

Then, we set $r_1 = 0.02$ and show impact of r_B changes in Table 7. The result shows that as r_B increases, the farmer's planting area and all supply chain members' profits will decrease. However, the acquirer and core enterprise purchase prices will increase.

4.3. The Impact of Critical Parameters on Profit Gap between Two Financing Modes. The sensitivity analysis results of the critical variables have been shown previously. The impact of the transmission-fee rate and interest rate involved in B mode on the profit gap of both financing modes will be examined next. We assumed that relevant parameters are $r_E = 0.06$ and $r_A = 0.12$ based on China's benchmark interest rate and practical applications. The implications of a farmer's bank financing ability on the performance of

Table 3: Parameter estimation results.

Parameters	Soybean	Wheat
a	7.343	2.136
b	0.000008701	0.000000005236
c	243.723	119.2888

Table 4: The impact of r_A on decision variables and supply chain profits.

r_A	q_A^*	ω_A^*	ψ_A^*	π_F^{A*}	π_S^{A*}	π_R^{A*}
0.04	11.8015	1.6495	3.2991	35303	70605	157150
0.08	11.6011	1.6839	3.3054	35426	69539	154480
0.12	11.4073	1.7171	3.3115	35521	68504	151900

Table 5: The impact of r_E on decision variables and supply chain profits.

r_E	q_A^*	ω_A^*	ψ_A^*	π_F^{A*}	π_S^{A*}	π_R^{A*}
0.00	11.6011	1.7462	3.3054	36738	69539	154480
0.03	11.4551	1.7243	3.3100	35819	68760	152540
0.06	11.3128	1.7029	3.3145	34935	67998	150640

Table 6: The impact of r_1 on decision variables and supply chain profits.

r_1	q_B^*	ω_B^*	ψ_B^*	π_F^{B*}	π_S^{B*}	π_R^{B*}
0.00	11.2199	1.6587	3.3174	33749	67499	149410
0.04	11.0386	1.6912	3.3231	33855	66523	146990
0.08	10.8630	1.7227	3.3287	33937	65574	144650

Table 7: The impact of r_B on decision variables and supply chain profits.

r_B	q_B^*	ω_B^*	ψ_B^*	π_F^{B*}	π_S^{B*}	π_R^{B*}
0.03	11.8015	1.6654	3.2991	35642	70605	157150
0.06	11.5034	1.6697	3.3085	34831	69018	153180
0.10	11.1285	1.6751	3.3203	33805	67007	148190

agricultural supply chain members in various scenarios are examined separately in the following sections. (I) Let $r_B = 0.10$ and $r_B > r_E$, i.e., the bank financing capacity of the farmer remains weak. (II) Let $r_B = 0.06$ and $r_B = r_E$, i.e., the farmer has the same bank financing ability as the acquirer. (III) Let $r_B = 0.03$ and $r_B < r_E$, i.e., the farmer can leverage the role of core enterprise to obtain bank loans at a lower interest rate in the three-tier supply chain.

4.3.1. The Farmer's Profit Gap. Figure 3 illustrates, for a given transmission-fee rate, the profit gap of the farmer under the two financing modes with varying bank financing capacities.

When the farmer's bank financing ability is less than the acquirer's, the farmer will not apply the B mode. When the farmer's bank financing ability is more than or equal to the acquirer's, the farmer will only select B mode if the transmission-fee rate falls within a certain range, which is consistent with Proposition 4, and Figures 4 and 5 demonstrate similar outcomes.

Moreover, when the bank loan interest rate remains constant, the profitability of the farmer under B mode grows as the transmission-fee rate rises. In other words, the higher the transmission-fee rate, the greater the farmer's motivation to finance through the B mode. It implies that increasing the transmission-fee rate is an effective method to encourage B mode and enhance the willingness of upstream enterprises in the agricultural supply chain to participate.

4.3.2. The Acquirer's Profit Gap. As shown in Figure 4, when the farmer's bank financing ability is constant, the profitability of the acquirer under the B mode decreases as the transmission-fee rate increases.

We also found that when the profitability of the acquirer is constant, the acquirer will offer a higher transmission-fee rate to the farmer as their bank financing ability increases. Overall, the profitability of the acquirer under the B mode always decreases with the transmission-fee rate increase. At this point, the farmer pays a higher capital cost but receives a higher purchase price. Profits for the acquirer are generated by the transmission fee and the selling of agricultural products. Therefore, when the sales revenue surrendered by the acquirer is not enough to cover the increased revenue from the transmission fee, it will decrease the total profit.

4.3.3. The Core Enterprise's Profit Gap. As seen from Figure 5, when the farmer's ability to get bank loans stays unchanged, the transmission-fee rate will reduce the profitability of the core enterprise under the B mode.

The increasing transmission-fee rate will decrease the profitability of the core enterprises. The reason is that the acquirer will seek a higher purchase price from the core enterprise. In summary, from the perspective of the agricultural supply chain, the acquirer can transfer the revenue of the downstream core enterprise to the upstream farmer by increasing the transmission-fee rate under B mode. In other words, the B mode can enable the upstream firm to enhance its revenue by reducing the core enterprise's power advantage as the game leader.

In addition, both Figures 4 and 5 demonstrate that while the transmission-fee rate is constant, the profitability of the acquirer and the core enterprise increases as the bank loan interest rate of the farmer decreases. Therefore, they are incentivized to help the farmer negotiate for a lower bank interest rate. However, decreasing the transmission-fee rate has good or negative implications for the profitability of all agricultural supply chain participants. It can be inferred that the alternative of supporting the farmer to lower the interest rate will be more effective if government departments encourage blockchain technology by subsidizing B mode because it can assist to reduce conflicts of interest among the members of the three-tier supply chain and increase the profitability of all supply chain participants.

5. Managerial Insights and Practical Implications

The financing mode helps to solve the issue of SMEs' financial constraints. When faced with a choice, the farmer anticipates that the selected financing mode will have minimal expenses

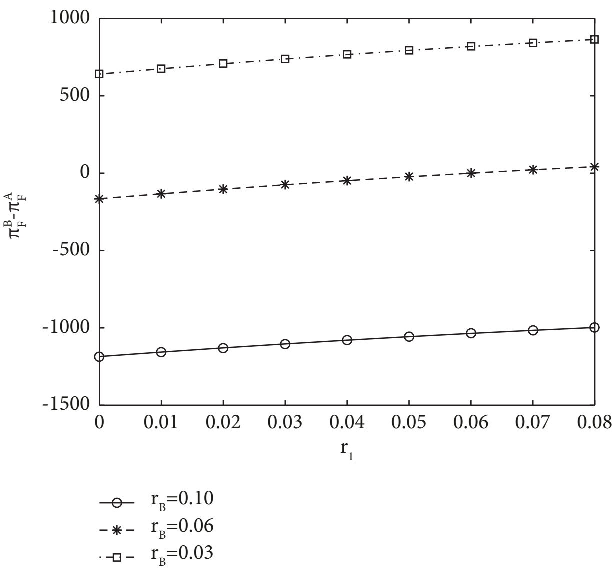

Figure 3: Change of the farmer's profit under different financing modes.

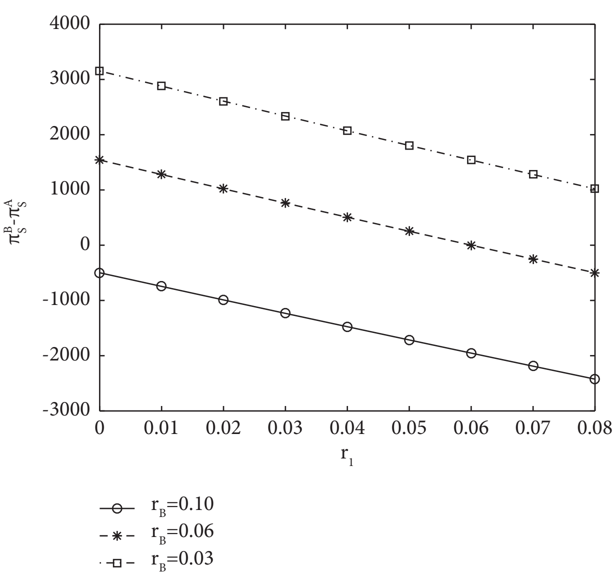

Figure 4: Change of acquirer's profit under different financing modes.

and generate high profits. Considering that financing costs can be immediately observed in the form of interest rate or transmission-fee rate, it is likely that the farmer will miss the financing mode that may bring higher profits between advance payment and blockchain-enabled financing mode. A farmer, for instance, may select the advance payment and reject the blockchain-enabled financing mode due to the high transmission-fee rate. According to our findings, however, a high transmission-fee rate also drives the acquirer to increase their buy price and, consequently, the farmer's profits. Therefore, when promoting blockchain-enabled financing mode, companies or the government must attract attention to this issue so that farmers are aware of the potential profits and select the most suitable financing mode.

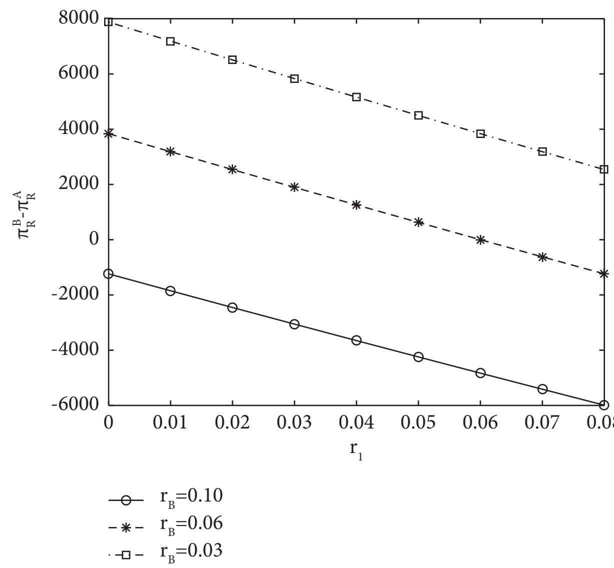

Figure 5: Change of core enterprise's profit under different financing modes.

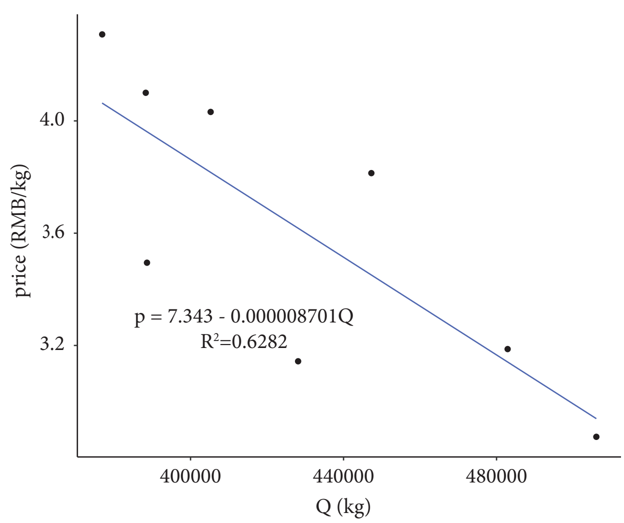

Figure 6: Scatter plot and fitted curve of soybean price vs. production.

For governments, supporting the acceptance of new financing modes can accelerate the development of new technologies. However, policies must be carefully designed to establish which of the three tiers of the supply chain is the most effective subsidy target. In the early stages of new technology development, governments frequently provide subsidized fees to encourage firms to adopt new technologies. However, it is preferable to help farmers rather than other companies. According to our findings, lowering the bank interest rate in the blockchain-enabled financing mode has a positive influence on all three tiers of the supply chain. Lowering the transmission-fee rate will negatively impact some members. It indicates that companies implementing new technologies and financing modes must be effectively informed and guided to completely comprehend the distinctions between the two financing modes and reach a win-win situation.

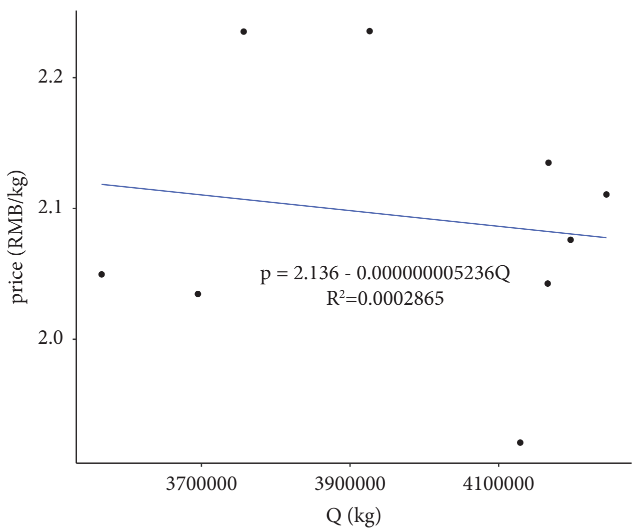

Figure 7: Scatter plot and fitted curve of wheat price vs. production.

6. Conclusions and Outlook

The use of supply chain finance to solve the issue of upstream financial constraints for core firms has been a widely discussed topic. The recent development of blockchain technology presents a further potential for addressing the three-tier funding constraint in the supply chain. This article compares and analyses two financing modes for addressing the upstream financing constraint problem in a three-tier supply chain: the traditional advance payment and the blockchain-enabled financing mode. The latter does not seem to dominate fully, but the appropriate transmission-fee rate setting does lead to more profits for all participants in the three-tier supply chain.

Specifically, we constructed a three-tier agricultural supply chain that included the capital-constrained farmer, the acquirer, and the core enterprise. The decisions and profits of the three members under the advance payment and the blockchain-enabled financing mode are investigated, then the two financing modes are compared. The findings indicate as follows:

(1) The premise underlying the farmer's choice of the blockchain-enabled financing mode is that their bank financing ability is stronger under this mode. Because supply chain finance will play the role of core enterprises, it lowers the financing rate and enhances the financing ability of SMEs. The blockchain-enabled financing mode can extend the advantages of supply chain finance to remote farmers in the three-tier supply chain and improve their bank financing ability, so the premise holds.

(2) Other members have also influenced the introduction of the blockchain-enabled financing mode in the agricultural supply chain. The transmission-fee rate should fall within a specific range to establish a win-win situation for all three participants. Specifically, a transmission-fee rate that is too low will decrease the farmer's profitability. At the same time, a transmission-fee rate that is too high will reduce the profitability of the acquirer and core enterprise.

(3) To promote the application of blockchain technology by the blockchain-enabled financing mode, government departments should provide targeted policy subsidies to the farmer rather than other members. It will further reduce the farmer's bank loan interest rate and improve their financing ability.

For future deep-tier supply chain finance research, some suggestions are presented. First, our work explores the supply chain of a single farmer. Future research can be extended to the supply chain model that includes multiple farmers [31] to address other open questions. Second, demand uncertainty and the risk of bankruptcy [9, 14] for the farmer have not been considered. It will be interesting to deepen the mathematics to explore differences in financing modes in terms of robustness [32–36], stochasticity [37], etc. Finally, this article assumes that the acquirer can pass the electronic flow certificate to the farmer in the blockchain-enabled financing mode. Various supply chain finance tools, such as guarantee and reverse factoring [12], could be considered in future research.

Appendix

A. Proof Process of Propositions

Proof 1. According to equations (9) and (20), we have the following equation:

$$\omega_B^* - \omega_A^* = \frac{ac}{\mathbb{Z}}\left[r_1\left(b\mu^2 + 2c + 2cr_E\right) - \left(r_A - r_B\right)b\mu^2 - 2c\left(r_A - r_E\right)\left(1 + r_B\right)\right], \quad \text{(A.1)}$$

Here $\mathbb{Z} = [b\mu^2 + 4c(1 + r_B) + 2cr_1] * \{2c[2(1 + r_A) - (r_A - r_E)] + b\mu^2\}$.

Let $\omega_B^* - \omega_A^* = 0$, we can obtain the following equation:

$$\widehat{r}_0 = \frac{(r_A - r_B)b\mu^2 + 2c(r_A - r_E)(1 + r_B)}{b\mu^2 + 2c + 2cr_E}. \quad \text{(A.2)}$$

Based on the assumption $r_B + r_1 < r_A$, we have $(r_A - r_B)b\mu^2 > r_1 b\mu^2$. Therefore, we can obtain the following equation:

(1) When $r_B < r_E$, if $r_1 > \widehat{r}_0$, we have the following equation:

$$r_1\left(b\mu^2 + 2c + 2cr_E\right) - \left(r_A - r_B\right)b\mu^2 - 2c\left(r_A - r_E\right)\left(1 + r_B\right) > 0, \tag{A.3}$$

i.e., $\omega_B^* > \omega_A^*$. Similarly, if $r_1 < \widehat{r}_0$, $\omega_B^* < \omega_A^*$. If $r_1 = \widehat{r}_0$, $\omega_B^* = \omega_A^*$.

(2) When $r_B \geq r_E$, we have $r_A - r_E \geq r_A - r_B > r_1$ and $1 + r_E \leq 1 + r_B$, i.e.,

$$r_1\left(1 + r_E\right) < \left(r_A - r_E\right)\left(1 + r_B\right), \tag{A.4}$$

So, $r_1\left(b\mu^2 + 2c + 2cr_E\right) - \left(r_A - r_B\right)b\mu^2 - 2c\left(r_A - r_E\right)\left(1 + r_B\right) < 0$ holds, i.e., $\omega_B^* < \omega_A^*$ holds. □

Proof 2. According to equations (10) and (21), we have the following equation:

$$\psi_B^* - \psi_A^* = \frac{acb\mu^2\left[r_1 - \left(r_A + r_E - 2r_B\right)\right]}{\mathbb{Z}}. \tag{A.5}$$

Let $\psi_B^* - \psi_A^* = 0$, we can obtain $\widehat{r}_1 = r_A + r_E - 2r_B$.

Based on the assumption $r_B + r_1 < r_A$, we have the following:

(1) When $r_B \leq r_E$, $r_1 - \left(r_A + r_E - 2r_B\right) = r_1 - \left(r_A - r_B + r_E - r_B\right) < 0$ holds, i.e., $\psi_B^* < \psi_A^*$ holds.

(2) When $r_B > r_E$, if $r_1 > \widehat{r}_1$, we have $r_1 - \left(r_A + r_E - 2r_B\right) > 0$, i.e., $\psi_B^* > \psi_A^*$. Similarly, if $r_1 < \widehat{r}_1$, $\psi_B^* < \psi_A^*$. If $r_1 = \widehat{r}_1$, $\psi_B^* = \psi_A^*$. □

Proof 3. According to equations (8) and (19) and assumption (3), we have the following equation:

$$Q_B^* - Q_A^* = \frac{ac\mu\left(r_A + r_E - 2r_B - r_1\right)}{\mathbb{Z}}. \tag{A.6}$$

Let $Q_B^* - Q_A^* = 0$, we can obtain $\widehat{r}_2 = r_A + r_E - 2r_B = \widehat{r}_1$. Based on the assumption $r_B + r_1 < r_A$, then we have the following:

(1) When $r_B \leq r_E$, $r_A + r_E - 2r_B - r_1 = r_A - r_B + r_E - r_B - r_1 > 0$ holds, i.e., $Q_B^* > Q_A^*$ holds.

(2) When $r_B > r_E$, if $r_1 > \widehat{r}_2$, we have $r_A + r_E - 2r_B - r_1 < 0$, i.e., $Q_B^* < Q_A^*$. Similarly, if $r_1 < \widehat{r}_2$, $Q_B^* > Q_A^*$. If $r_1 = \widehat{r}_2$, $Q_B^* = Q_A^*$. □

Proof 4. According to equations (11) and (22), we have the following equation:

$$\pi_F^{B*} - \pi_F^{A*} = \frac{a^2\mu^2 c}{4\left(N + 2cr_1\right)^2 M^2}\left[\left(1 + r_B + r_1\right)M^2 - \left(1 + r_A\right)\left(N + 2cr_1\right)^2\right]. \tag{A.7}$$

Let $\pi_F^{B*} - \pi_F^{A*} = 0$, we can obtain $\widehat{r}_3$ and $\widehat{r}_4$. □

Proof 5. According to equations (12) and (23), we have the following equation:

$$\pi_S^{B*} - \pi_S^{A*} = \frac{a^2\mu^2 c}{4\left(N + 2cr_1\right)^2 M^2}\left\{\left[2\left(1 + r_B\right) + r_1\right]M^2 - \left(2 + r_A + r_E\right)\left(N + 2cr_1\right)^2\right\}. \tag{A.8}$$

Let $\pi_S^{B*} - \pi_S^{A*} = 0$, we can obtain $\widehat{r}_5$. □

Proof 6. According to equations (13) and (24), we have the following equation:

$$\pi_R^{B*} - \pi_R^{A*} = \frac{2a^2\mu^2 c\left(r_A + r_E - 2r_B - r_1\right)}{4\mathbb{Z}}. \tag{A.9}$$

Let $\pi_R^{B*} - \pi_R^{A*} = 0$, we can obtain $\widehat{r}_6$. □

B. Scatter Plots and Fitting Curves of Different Crop Price and Production

Here, we provided scatter plots and fitted curves on market prices versus production for the last nine years for both crops (Figures 6 and 7). Raw price, production, and cost data are from the Chinese Ministry of Agriculture and Rural Affairs website (https://zdscxx.moa.gov.cn:8080/nyb/pc/index.jsp). Consumer price index data are from the website of the National Bureau of Statistics (https://www.stats.gov.cn/).

Data Availability

We have provided scatter plots and fitted curves on market prices versus production for both crops using data from 2011–2019. Raw price, production, and cost data are from the Chinese Ministry of Agriculture and Rural Affairs website (https://zdscxx.moa.gov.cn:8080/nyb/pc/index.jsp). Consumer price index data are from the website of the National Bureau of Statistics (https://www.stats.gov.cn/).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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