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Research on Optimal Decision-making of E-commerce Agricultural Products Supply Chain under Information Asymmetry

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Abstract

This paper combines blockchain technology with agricultural product e-commerce supply chain to study the problem of applying blockchain to coordinate e-commerce agricultural product supply chain when suppliers conceal the true freshness of agricultural products. Considering a secondary supply chain composed of a supplier and a retail e-commerce, a supply chain decision model is constructed under the information symmetry of freshness, the asymmetry of freshness information and the application of blockchain technology. The motivation of suppliers to conceal the true freshness information of agricultural products is analyzed, and the influence of blockchain cost threshold on the overall profit of the supply chain is discussed. Find out the retail e-commerce order quantity and online sales price when the supply chain profit is optimal under the application of blockchain technology. Studies have proved that suppliers' concealment of true freshness information will damage retail e-commerce profits and is not conducive to the stability of the supply chain. The results show that the application input cost of blockchain technology has a significant impact on the overall profit of the supply chain. The smaller the input cost of blockchain technology application, the higher the total profit of the supply chain under the application of blockchain technology. Within a certain range of cost threshold, the total profit of the supply chain under the application of block chain technology is greater than that of the supply chain with asymmetric freshness information.

Keywords

Asymmetric Freshness Information; Block Chain; Agricultural Product Supply Chain; Ordering Decision.

1. Introduction

China's fresh e-commerce industry is in a period of rapid development, and the market potential is huge. According to the 47th Statistical report on the Development of China's Internet released by the China Internet Network Information Center, as of December 28, 2020, the number of online shopping users in China has reached 782 million, accounting for 79.1% of the total Internet users; the number of mobile online shopping users has reached 781 million, accounting for 79.2% of mobile Internet users; the rise of online shopping has continuously cultivated new momentum in the consumer market, creating conditions for the development of fresh e-commerce. At present, more and more enterprises join the field of fresh e-commerce, and the competition is becoming more and more fierce. Fresh products belong to the necessities of daily life, with the characteristics of short shelf life, high consumption frequency and high fresh-keeping requirements. Affected by the epidemic in 2020, consumers are no longer limited to the traditional offline purchase of fresh consumption habits. Instead, fresh agricultural products are purchased through online channels. According to Fastdata

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pole data, the transaction volume of fresh e-commerce reached 184.12 billion yuan in the first half of 2020, an increase of nearly 137.6% compared with the same period in 2019. At present, a variety of fresh e-commerce platforms have emerged in the market. the main operation modes include: e-commerce supermarkets (Taoxianda, Yonghui Life, JD.com supermarket, Tmall supermarket, SUNING fresh, etc.), vertical e-commerce (daily excellent fresh, box horse fresh, COFCO I buy net, Shunfeng selection, etc.), O2O (box Ma Xiansheng, Meituan buy vegetables, Ding Dong buy vegetables, baby elephant fresh, etc.). However, the development of fresh e-commerce not only changes the consumer demand and habits of consumers, but also faces some problems, which is bound to affect the decision-making of the members of the supply chain. For example, according to the survey report on the consumption of fresh e-commerce released by the Beijing consumers Association, the most fresh goods purchased by the respondents online are fruits and vegetables, and the more prominent problem encountered is that the goods are not fresh, accounting for 28.12%. Most of the respondents hoped to establish and improve the platform information feedback mechanism and service system, product quality and safety traceability system, fresh product standardization system and logistics system, and called on relevant departments to strengthen supervision over the fresh e-commerce industry. With the improvement of living standards and the change of consumption habits, consumers pay more and more attention to the quality and safety of agricultural products, and the demand for traceability of agricultural products from production to sales is gradually highlighted.

This paper mainly studies the problem of information asymmetry of freshness in e-commerce agricultural product supply chain. In the agricultural product supply chain, the freshness information is private to the supplier. In order to get more profits, the supply chain may falsely report the freshness. Based on the research problems of this paper, the structure of this paper is as follows: the second part is literature review, the third part is model hypothesis and decision model, the fourth part is example analysis, and the fifth part is the conclusion of this paper.

2. Literature References

As an emerging technology, blockchain technology is still in its infancy in various fields, but the trend of enterprises in various countries to increase R & D investment to explore the application of blockchain in the supply chain is increasing. Blockchain technology has the characteristics of decentralization, data security can not be tampered with, intelligent contract, high transparency and so on[1]. The application of blockchain technology can improve the efficiency of the supply chain and solve the problems of unequal information and lack of trust among members of the agricultural supply chain. Research shows that the implementation of blockchain technology in food supply chain can reduce transaction costs[2], improve product quality and ensure food safety [3][4], improving the quality and level of information sharing [5] and involving more stakeholders will help to reduce the information asymmetry among supply chain members and increase the credibility of product label information, thus improving the external quality attributes of products [6] and increasing the profits of agricultural products supply chain [7],[8] proposed a supply chain intelligent quality management framework based on block chain to solve the problem of information asymmetry caused by lack of trust in the supply chain and better supervise the quality of supply chain products. [9] proposes an information sharing scheme based on blockchain. The platform system combines blockchain with homomorphic encryption to solve the problem of double marginalization in supply chain management and alleviate the negative impact of information asymmetry on supply chain coordination. The above literatures on blockchain research have conducted in-depth research from different perspectives, mainly including framework design [7][8], system construction [9], case analysis [6] and other qualitative analysis, but there is little literature on the quantitative research and analysis of the impact of blockchain technology application on fresh agricultural products supply chain ordering decision-making under the background of e-commerce.

Some scholars are concerned about the problem of information asymmetry in supply chain coordination. Information asymmetry refers to the situation in which some information held by supply chain members belongs to private information and is not shared with all supply chain members [10].

[11] consider the impact of demand information asymmetry on supply chain profits under decentralized decision-making mode. [12] study a two-tier supply chain consisting of a manufacturer and a retailer, considering that the retailer's holding cost is private information. This paper constructs a quantity discount contract model based on stackelberg game to minimize the manufacturer's cost, and proves that the quantity discount contract can help to coordinate the supply chain in the case of asymmetric cost information. [13] comparing the profit differences of supply chain members under complete information and asymmetric information, this paper evaluates the impact of information sharing on supply chain performance, and discusses how to design a revenue sharing contract to alleviate the cost information asymmetry in the supply chain. [14][15] studied the situation that manufacturers have private production cost information and retailers have private demand information. The study found that in the case of bilateral information asymmetry, commitment penalty contracts can effectively force retailers and manufacturers to disclose their private information, achieve their own maximum profits, and maximize the overall benefits of the supply chain. [15] this paper studies the supply chain composed of a manufacturer and a retailer whose sales cooperation is carried out in an infinite time range under asymmetric demand information. A small amount of literature has studied the problem of quality information asymmetry in the supply chain. [16] consider a supply chain model composed of a supplier and a buyer, and study the relationship between the supplier's market value concern and private quality cost information. The results show that the market value concern of suppliers is helpful to alleviate the adverse effects of quality information asymmetry. When the supplier pays more attention to the market value, it will benefit the buyer and the whole chain system. Most of the researches are mainly related to cost information asymmetry [12][13] and demand information asymmetry [14][16];. They mainly discuss how to reduce the negative impact of information asymmetry and realize supply chain coordination through supply chain contract. There is little literature on the impact of agricultural product freshness information asymmetry on supply chain performance. The above research coordinates the supply chain through contracts, while this paper mainly uses block chain technology to coordinate the supply chain to ensure that suppliers share accurate freshness information and alleviate the adverse effects of asymmetric freshness information.

In this study, a supply chain model with asymmetric freshness information is established to study the impact of supply freshness information asymmetry on fresh agricultural products supply chain ordering decision-making and overall profits. Considering the asymmetry of freshness information, the optimal order quantity and pricing decision of e-commerce agricultural product supply chain are obtained. At the same time, the influence of the application cost threshold of blockchain technology on the profit of supply chain is discussed.

3. Problem Description and Symbolic Description

Consider a two-level supply chain composed of a supplier and a retail e-commerce platform to launch the Stackelberg game, with the supplier as the leader of the Stackelberg game. the process of the game is as follows: the supplier produces a kind of agricultural products with a unit production cost of c_s, and gives the unit wholesale price w and freshness θ of agricultural products according to the output and previous experience, and the retailer gives the wholesale price and freshness information of agricultural products given by the supplier. Combined with the operating cost of e-commerce platform, determine the order quantity and online sales price. The agricultural products studied in this paper have the characteristics of long production cycle and easy deterioration, and the freshness of agricultural products is the private information of suppliers. In order to protect their own interests, they may falsely report the freshness of agricultural products, resulting in the loss of retail e-commerce platform. This part mainly considers the information asymmetry of freshness in the e-commerce perishable agricultural product supply chain.

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Table 1. description of model parameter symbols

Parameters	Meaning
w	Wholesale price of agricultural products per unit
p	unit online selling price of agricultural products
q	Retail e-commerce order quantity
c_s	supplier agricultural product unit production cost
c_r	retail e-commerce unit operating cost
c_b	Block chain application cost
π_c	Total profit of supply chain
π_s	Supplier profit
π_r	Retail e-commerce profit
$c(\theta)$	Retail e-commerce profit
T	Life cycle of agricultural products
θ	Freshness of agricultural products
t	Production time of agricultural products
λ	False statement coefficient, 0< λ <1,when$\lambda = 1$, the supplier truthfully announced, Superscript λ means supplier conceals the freshness information.
$*$	Represent the best
Superscript a	Retailer's actual decision-making Model under false report behavior

Hypothesis 1: According to the research [17][18] and combined with the actual research problems in this paper, the market demand is mainly affected by online sales price and product freshness, and the market demand function is given as follows:

$$D = a + bp - k\theta$$

a represents potential market demand, $b > 0$ represents price sensitivity coefficient, and $k > 0$ represents freshness sensitivity coefficient.

Hypothesis 2: Reference [16] Assume that the functional relationship between the freshness of agricultural products θ and production time t is:

$$\theta(t) = 1 - \frac{t^2}{T^2}, 0 \leq t \leq T$$

Hypothesis 3: Referring to the functional relationship between freshness of agricultural products and freshness cost [19], the freshness cost of agricultural products can be expressed as:

$$c(\theta) = \frac{\sigma\theta^2}{2}$$

σ is the preservation cost coefficient.

Hypothesis 4: The supplier is a producer of agricultural products, master the information of the whole production process of agricultural products, be responsible for the freshness of agricultural products, and bear the corresponding cost of freshness of agricultural products; When placing an order, the

Volume 8 Issue 3, 2022
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retail e-commerce company obtains the product production time information from the supplier and undertakes the operating cost of the e-commerce platform. For the study results to be meaningful, assume that the set variables are satisfied $p > w + c_s + c_r$,$a > b(c_s + c_r)$.

3.1 Basic Model Decision under Information Symmetry

The supplier shares the real freshness information of agricultural products with the retail e-commerce, and the freshness cost is $c(\theta)$. The retail e-commerce determines the corresponding order quantity of agricultural products according to the freshness information of agricultural products provided by the supplier combined with the market demand function. In this case, the profits of suppliers and retail e-tailers are:

$$\pi_s = (w - c_s)q - c(\theta) \tag{1}$$

$$\pi_r = (p - w - c_r)q \tag{2}$$

According to backward induction, the optimal order quantity and online sales price are:

$$q^* = \frac{a + k\theta - b(w + c_r)}{2} \tag{3}$$

$$p^* = \frac{a + k\theta + b(w + c_r)}{2b} \tag{4}$$

Substitute the formula (3) into the supplier profit function, take the second derivative of w to obtain $\frac{\partial^2 \pi_s}{\partial w^2} = -2b < 0$, and the optimal solution exists. Set $\frac{\partial \pi_s}{\partial w} = 0$, and the optimal supplier wholesale price under the condition of asymmetric freshness information is:

$$w^* = \frac{a + k\theta + b(c_s - c_r)}{2b} \tag{5}$$

$$q^* = \frac{a + k\theta - b(c_s + c_r)}{4} \tag{6}$$

$$p^* = \frac{3a + 3k\theta + b(c_s + c_r)}{4b} \tag{7}$$

Put formula (6) and (7) into the equation to obtain the total profit of suppliers, retail e-commerce and supply chain:

$$\pi_s^* = \frac{[a + k\theta - b(c_s + c_r)]^2 - 4b\sigma\theta^2}{8b} \tag{8}$$

$$\pi_r^* = \frac{[a + k\theta - b(c_s + c_r)]^2}{16b} \tag{9}$$

$$\pi_c^* = \pi_s^* + \pi_r^* \tag{10}$$

3.2 Decision Model under Information Asymmetry

Since the freshness of agricultural products is the supplier's private information, in order to maximize profits and reduce the fresh-keeping cost, the freshness of agricultural products is falsely reported to

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retailers, and the fresh-keeping cost is $c(\theta)$. It is assumed that the supplier falsely reports the production time of agricultural products to the retailer as λt, where the coefficient $\lambda \in [0,1]$ is falsely reported. The retailer orders agricultural products according to the freshness information provided by the supplier, and the order quantity of agricultural products under the false reporting behavior is q^{λ}.In this case, supplier profit model, actual profit model of retail e-commerce and decision-making model of retail e-commerce are as follows:

$$\pi_s^{\lambda} = (w - c_s)q^{\lambda} - c(\theta) \tag{11}$$

$$\pi_r^{\lambda a} = (p - w - c_r)q - \left(q^{\lambda} - q\right)(w + c_r) \tag{12}$$

$$\pi_r^{\lambda} = (p - w - c_r)q^{\lambda} \tag{13}$$

According to backward induction, the optimal order quantity and online sales value of retail e-commerce under decentralized decision making with asymmetric freshness information can be obtained as follows:

$$q^{\lambda*} = \frac{a + k\theta^{\lambda} - b(w + c_r)}{2} \tag{14}$$

$$p^{\lambda*} = \frac{a + k\theta^{\lambda} + b(w + c_r)}{2b} \tag{15}$$

Put the optimal order quantity into the supplier's profit function to sort out:

$$\pi_s^{\lambda} = \frac{(w - c_s)[a + k\theta^{\lambda} - b(w + c_r)]}{2} - c(\theta) \tag{16}$$

Take $\frac{\partial \pi_s^{\lambda}}{\partial w} = 0$ to obtain the supplier's optimal wholesale price under the condition of asymmetric freshness information:

$$w^{\lambda*} = \frac{a + k\theta^{\lambda} + b(c_s - c_r)}{2b} \tag{17}$$

Put the above formula into the optimal order quantity and the optimal online sales price:

$$q^{\lambda*} = \frac{a + k\theta^{\lambda} - b(c_s + c_r)}{4} \tag{18}$$

$$p^{\lambda*} = \frac{3a + 3k\theta^{\lambda} + b(c_s + c_r)}{4b} \tag{19}$$

Substituting (17), (18) and (19) into (11) and (12), the actual profits of suppliers and retail e-commerce and the total profits of supply chain are as follows:

$$\pi_s^{\lambda *} = \frac{\left[a + k\theta^{\lambda} - b(c_s + c_r)\right]^2 - 4b\sigma\theta^2}{8b} \tag{20}$$

$$\pi_r^{\lambda *} = \{[a + k\theta - b(c_s + c_r)][a + k\theta^{\lambda} - b(c_s + c_r)] - 2k\left(\theta^{\lambda} - \theta\right)[a + k\theta^{\lambda} + b(c_s + c_r)]\}/16b \tag{21}$$

$$\pi_c^{\lambda *} = \pi_s^{\lambda *} + \pi_r^{\lambda *} \tag{22}$$

Proposition 1: Suppliers falsely report agricultural products falsely report the production time of agricultural products, which will lead to: retailers will increase the order quantity of agricultural products, resulting in certain sales losses and unable to achieve optimal profits; In the case of suppliers misreporting the freshness information of agricultural products, it can save the freshness cost of agricultural products and obtain more profits.

Proof: (1) Given the functional relation between freshness and production time:

$$\theta(t) = 1 - \frac{t^2}{T^2}(0 \le t \le T)$$

$\frac{\partial \theta}{\partial t} = -\frac{2t}{T^2} < 0$ Can be deduced, the freshness of agricultural products is negatively correlated with production time t, and the freshness of agricultural products decreases with the increase of production time. It is known that in the case of asymmetric freshness information, the supplier falsely reported the production time of agricultural products as λt, and the corresponding freshness is θ(λt) simplified to θ^{λ}, and λ∈(0,1), the lower the false reporting coefficient, the lower λt, the higher the freshness of agricultural products.

Given that the freshness under information symmetry is θ, it can be deduced that:

$$\lambda t < t \Rightarrow \theta(\lambda t) > \theta(t) \Rightarrow \theta^{\lambda} > \theta$$

The optimal order quantity formula (18) of retail e-commerce under information asymmetry is known. By taking the first-order derivative of freshness θ^{λ},i.e. $\frac{\partial q^{\lambda *}}{\partial \theta^{\lambda}} = k > 0$, the order quantity of retail e-commerce is positively correlated with freshness of agricultural products. Therefore, the higher freshness of agricultural products provided by suppliers to retailers, the greater the order quantity.

By above knowable $\theta^{\lambda} > \theta$, is derived, so the $\frac{q^{\lambda *}}{q*} = \frac{a+k\theta^{\lambda}-b(c_s+c_r)}{a+k\theta-b(c_s+c_r)} > 0$, then under the supplier lying about the freshness information, retail electricity quantity $q^{\lambda *} > q^*$, Because the actual market demand is less than $q^{\lambda *}$q, there will be a certain loss of sales.

Therefore, it is concluded that when suppliers misreport the freshness of agricultural products, retailers will increase the quantity of agricultural products ordered according to the market demand function, resulting in a certain loss of profits and unable to achieve optimal profits.

Proof: (2) The function relation between the freshness cost and freshness of agricultural products is known: $c(\theta) = \frac{\sigma\theta^2}{2}$.Take the first derivative of freshness, $\frac{\partial c}{\partial \theta} = \sigma\theta > 0$. The freshness of agricultural products is positively correlated with the cost of keeping fresh: $c(\theta^{\lambda}) > c(\theta)$, The fresh-keeping cost in the actual profit function of the supplier falsely reporting freshness information is $c(\theta)$, and the saved fresh-keeping cost of agricultural products is $c\left(\theta^{\lambda}\right) - c(\theta)$.

Therefore, it is concluded that in the case of suppliers lying about the freshness information of agricultural products, suppliers lying about the production time of agricultural products can save the fresh-keeping cost and gain more profits. Proposition 1 is proved.

Proposition 2: Under the condition of asymmetric freshness information, retailer's profit decreases with the increase of supplier's false freshness θ^{λ}, while supplier's profit increases with the increase of θ^{λ}.

Proof: $\frac{\partial \pi_r^{\lambda *}}{\partial \theta^{\lambda}} = -ak + k^2\theta - 3b(c_s + c_r) - 4k^2\theta^{\lambda} < 0$, $\pi_r^{\lambda *}$ is negatively correlated with θ^{λ}, the higher the freshness of agricultural products falsely reported by suppliers, the lower the actual profits of retail e-commerce $\frac{\partial \pi_s^{\lambda *}}{\partial \theta^{\lambda}} = 2a - 2b(c_s + c_r) + 2k^2\theta^{\lambda}$, $a > b(c_s + c_r)$, Supplier profit increases as θ^{λ} increases.

In conclusion, retailer's profit decreases with the increase of supplier's false report of fresh produce θ^{λ}, while supplier's profit increases with the increase of θ^{λ}.

3.3 Supply Chain Decision Model in the Context of Blockchain Technology

Building the information sharing system of agricultural supply chain of e-commerce under the application of blockchain technology can ensure that the freshness information of agricultural products shared by suppliers is true and reliable. Retail e-commerce can order appropriate quantity of agricultural products to sell according to the production time and market demand function of agricultural products. Consider the unit investment cost of blockchain technology shared by the manufacturer and retailer. The proportion of cost borne by suppliers is α, and that borne by retailers is $1 - \alpha$. It is assumed that the potential market demand of agricultural products with the application of blockchain technology is higher than the order quantity of agricultural products without the use of blockchain technology, that is, the market demand function $D_b = \gamma(a - bp + k\theta), \gamma > 1$, subscript b represents the application of blockchain technology.

Under the application of blockchain technology, the supplier will input the production time and storage information of agricultural products directly into the block in time. The information has the characteristics of being immutable. After the synchronization of each block, the information will be finally uploaded to the supply chain information system, so that retail e-commerce enterprises and consumers can learn the specific information of agricultural products. Therefore, there is no problem of suppliers misreporting the freshness of agricultural products. The profit function of suppliers and retail e-commerce under the application of blockchain technology is:

$$\pi_{sb} = (w_b - c_s - \alpha c_b)q_b - c(\theta) \tag{23}$$

$$\pi_{rb} = [p_b - w_b - c_r - (1 - \alpha)c_b]q_b \tag{24}$$

By backward induction $\frac{\partial^2 \pi_{rb}}{\partial {q_b}^2} = \frac{-2}{\gamma b} < 0$, There is an optimal solution, set $\frac{\partial \pi_{rb}}{\partial q_b}=0$, it can be deduced that:

$$q_b^* = \frac{\gamma\{a + k\theta - b[w_b + c_r + (1 - \alpha)c_b]\}}{2} \tag{25}$$

$$p_b^* = \frac{a + k\theta + b[w_b + c_r + (1 - \alpha)c_b]}{2b} \tag{26}$$

Substituting the optimal order quantity into the supplier profit function, the following equation can be obtained:

Volume 8 Issue 3, 2022
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$$\pi_{sb} = \{a + k\theta - b[w_b + c_r + (1-\alpha)c_b]\}(w_b - c_s - \alpha c_b)/2 - c(\theta) \tag{27}$$

Using the same method, the optimal wholesale price of the supplier's agricultural products under the application of blockchain technology is:

$$w_b^* = \frac{a + k\theta + b[c_s - c_r + (2\alpha - 1)c_b]}{2b} \tag{28}$$

Substituting (28) into (25) and (26), Optimal order quantity and optimal online price:

$$q_b^* = \frac{\gamma[a + k\theta - b(c_s + c_r + c_b)]}{4} \tag{29}$$

$$p_b^* = \frac{3a + 3k\theta + b(c_s + c_r + c_b)}{4b} \tag{30}$$

By bringing the above formula into the profit function of suppliers and retail e-commerce, the optimal profit of each member of the supply chain and the overall optimal profit can be obtained as follows:

$$\pi_{sb}^* = \frac{\gamma[a + k\theta - b(c_s + c_r + c_b)]^2 - 4b\sigma\theta^2}{8b} \tag{31}$$

$$\pi_{rb}^* = \frac{\gamma[a + k\theta - b(c_s + c_r + c_b)]^2}{16b} \tag{32}$$

$$\pi_{cb}^* = \frac{3\gamma[a + k\theta - b(c_s + c_r + c_b)]^2 - 8b\sigma\theta^2}{16b} \tag{33}$$

Proposition 1: Under the application of blockchain technology, the wholesale price of agricultural products suppliers is related to the application cost OF blockchain technology $c_b$and technology cost sharing ratio α.when $\alpha > \frac{1}{2}$, $c_b > \frac{k(\theta^\lambda - \theta)}{b(2\alpha-1)}$, Suppliers will raise wholesale prices, when $0 < c_b < \frac{k(\theta^\lambda - \theta)}{b(2\alpha-1)}$, Suppliers will lower wholesale prices.

Proof: Compare the supplier wholesale price expression (17) with the supplier wholesale price expression (28) with the information symmetry under the application of blockchain technology.

Case 1: $w_b^* > w^{\lambda *} \Rightarrow \frac{a+k\theta+\ [c_s-c_r+(2\alpha-1)c_b]}{2b} > \frac{a+k\theta^\lambda+b(c_s-c_r)}{2b}$.

$$\Rightarrow k\theta + bc_b(2\alpha - 1) > k\theta^\lambda \Rightarrow bc_b(2\alpha - 1) > k(\theta^\lambda - \theta)$$

When$2\alpha - 1 > 0,\ \alpha > \frac{1}{2}, c_b > \frac{k(\theta^\lambda - \theta)}{b(2\alpha-1)}$;

When$2\alpha - 1 < 0,\ 0 < \alpha < \frac{1}{2}$, it is known that $0 < b < 1$, so $c_b > 0$ is not valid, and the result does not meet the conditions of the original hypothesis.

Case 2:$w_b^* < w^{\lambda *} \Rightarrow \frac{a+k\theta+b[c_s-c_r+(2\alpha-1)c_b]}{2b} < \frac{a+k\theta^\lambda+b(c_s-c_r)}{2b}$.

$$\Rightarrow k\theta + bc_b(2\alpha - 1) < k\theta^{\lambda} \Rightarrow bc_b(2\alpha - 1) < k(\theta^{\lambda} - \theta)$$

When$2\alpha - 1 > 0,\ \alpha > \frac{1}{2}, 0 < c_b < \frac{k(\theta^{\lambda}-\theta)}{b(2\alpha-1)}$;

When$2\alpha - 1 < 0,\ 0 < \alpha < \frac{1}{2}, c_b > 0$,according to the wholesale price expression of suppliers under the application of blockchain (28), the higher the input cost of blockchain is, the higher the wholesale price of agricultural products is, which does not meet the conditions of the original hypothesis.

Therefore, it is concluded that the wholesale price of agricultural products suppliers is related to the application cost OF blockchain technology c_b and technology cost sharing ratio α. The greater the block chain input cost c_b, the higher the wholesale price of agricultural products. When $\alpha > \frac{1}{2}$, $c_b > \frac{k(\theta^{\lambda}-\theta)}{b(2\alpha-1)}$, suppliers will raise wholesale prices, $0 < c_b < \frac{k(\theta^{\lambda}-\theta)}{b(2\alpha-1)}$, suppliers will lower wholesale prices.

Proposition 2: When the cost of blockchain technology application $c_b > \frac{3k(\theta^{\lambda}-\theta)}{b}$, retailers will increase their online sales price; If $0 < c_b < \frac{3k(\theta^{\lambda}-\theta)}{b}$, the retailer will lower the online selling price.

Proof: By comparing equation (19) with equation (30), it can be known that:

$$p_b^* > p^{\lambda*} \Rightarrow \frac{3a + 3k\theta + b(c_s + c_r + c_b)}{4b} > \frac{3a + 3k\theta^{\lambda} + b(c_s + c_r)}{4b}$$
$$\Rightarrow bc_b > 3k\left(\theta^{\lambda} - \theta\right) \Rightarrow c_b > \frac{3k(\theta^{\lambda} - \theta)}{b}$$

Therefore, if $c_b > \frac{3k(\theta^{\lambda}-\theta)}{b}$, retailers will raise their online selling prices; Similarly, if $0 < c_b < \frac{3k(\theta^{\lambda}-\theta)}{b}$, retailers will lower the online selling price, which is proved by proposition 2.

Proposition 3: when $0 < c_b \frac{a+k\theta-b(c_s+c_r)-\sqrt{\frac{A}{3\gamma}}}{b}$, block chain technology application under the supply chain profit is greater than the fresh supply chain profit under information asymmetry, it means $\pi_{cb}^* > \pi_c^{\lambda*}$.

Proof: Obtained by formula (22) and (33):

$$\begin{aligned}
&\pi_{cb}^* > \pi_c^{\lambda*} \\
&\Rightarrow 3\gamma[a + k\theta - b(c_s + c_r + c_b)]^2 \\
&> \left[a + k\theta^{\lambda} - b(c_s + c_r)\right]\left[3a + k\left(2\theta^{\lambda} + \theta\right) - 3b(c_s + c_r)\right] \\
&- 2k\left(\theta^{\lambda} - \theta\right)\left[a + k\theta^{\lambda} + b(c_s + c_r)\right]
\end{aligned}$$

Let's put the inequality on the right-hand side= A.

$$\Rightarrow 3\gamma[a + k\theta - b(c_s + c_r + c_b)]^2 > \mathrm{A}$$
$$\Rightarrow\ a + k\theta - b(c_s + c_r + c_b) > \sqrt{\frac{A}{3\gamma}}$$
$$\Rightarrow \frac{a + k\theta - b(c_s + c_r) - \sqrt{\frac{A}{3\gamma}}}{b} > c_b$$

Volume 8 Issue 3, 2022
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Therefore, when $0 < c_b < \frac{a+k\theta- \ (c_s+c_r)-\sqrt{\frac{A}{3\gamma}}}{b}$, the overall profit of the supply chain under the application of blockchain technology is greater than the overall profit of the supply chain under the freshness information asymmetry, proposition 3 can be proved.

4. The Example Analysis

Assume that the parameters related to certain perishable agricultural products in the supply chain of e-commerce agricultural products are as follows: $c_s = 2, c_r = 1.3, a = 4000, b = 1800, k = 1600, t = 5, T = 12, \sigma = 1100, \lambda \in (0,1)$.

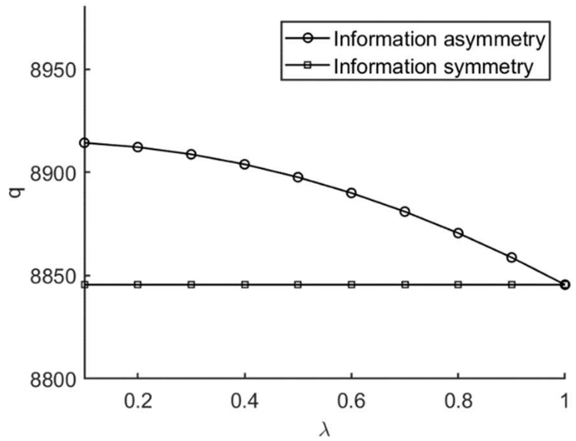

Fig. 1 The relationship between false reporting coefficient and order quantity

As can be seen from Fig. 1, in the case of suppliers' misreporting, the misreporting coefficient is negatively correlated with the order quantity. The lower the misreporting coefficient is, the higher the freshness of agricultural products is, and accordingly, the higher the order quantity of agricultural products of retail e-commerce enterprises is. When the supplier does not misreport, the misreport coefficient λ is 1, and the freshness of agricultural products and order quantity of retail e-commerce are lower than those under information asymmetry.

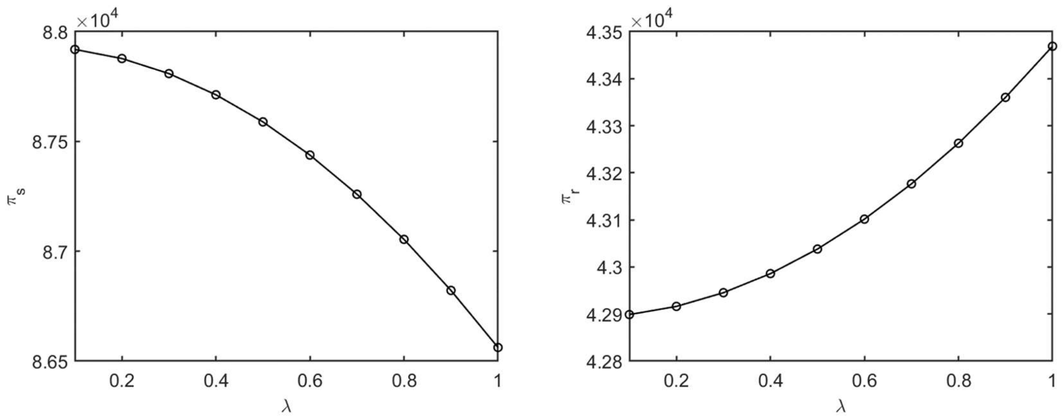

Fig. 2 Relationship between false reporting coefficient and profit of each member of supply chain

As can be seen from Fig. 2, suppliers' concealment of the true freshness of agricultural products will affect the profits of all members of the supply chain. The false reporting coefficient is negatively correlated with the supplier's profit, but positively correlated with the retail e-commerce profit. When

Volume 8 Issue 3, 2022
DOI: 10.6919/ICJE.202203_8(3).0065

the false reporting coefficient λ=0.1, the supplier's profit acquisition reaches the highest, while the retail e-commerce profit reaches the lowest.

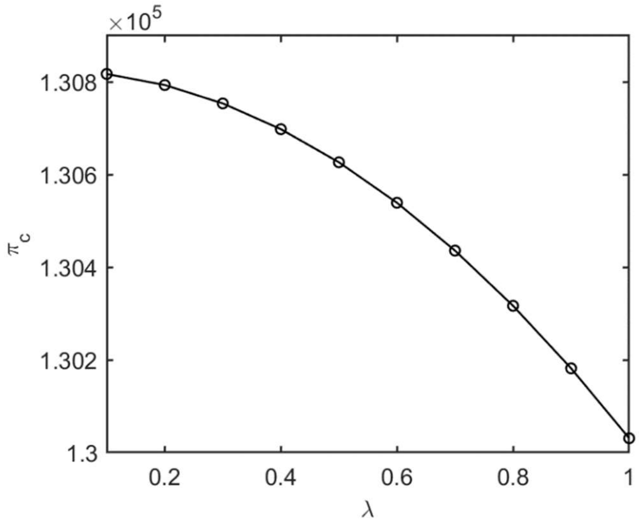

Fig. 3 Relationship between false reporting coefficient and supply chain profit

It can be seen from Figure 3 that the overall profit of the supply chain is affected by the supplier's misreporting behavior. The lower the misreporting coefficient is, the higher the overall profit of the supply chain is. However, the stability of the supply chain cannot be achieved because the profit of the retail e-commerce is damaged.

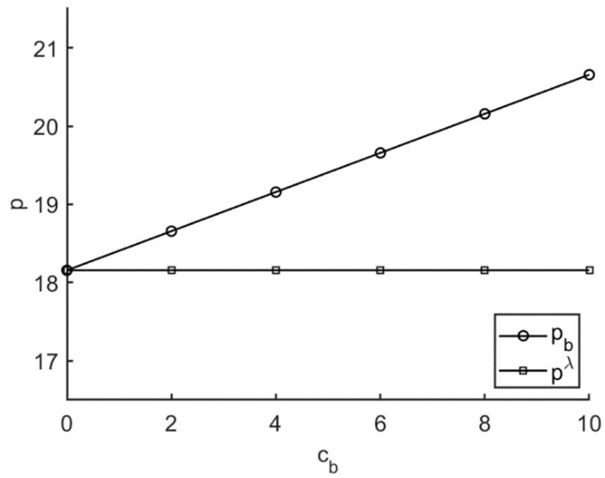

Fig. 4 The relationship between block chain unit cost and selling price

Under the assumption that the above parameters remain unchanged, the false reporting coefficient λ=0.1 is assumed to analyze the impact of blockchain cost on the ordering decisions of each member of the supply chain. As can be seen from Fig. 4, the unit cost of blockchain technology has a significant impact on the online sales price of retail e-commerce. The higher the cost threshold of blockchain technology is, the higher the online sales price is.

Volume 8 Issue 3, 2022
DOI: 10.6919/ICJE.202203_8(3).0065

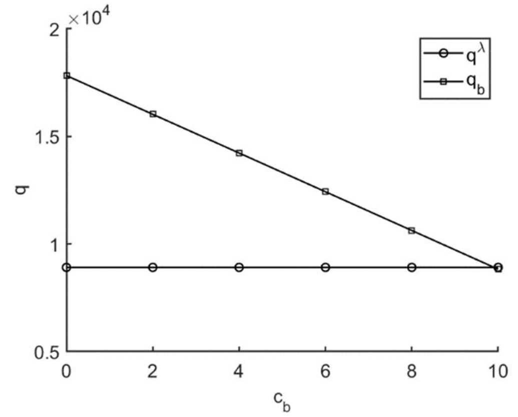

Fig. 5 The relationship between block chain unit cost and order quantity

It can be seen from Fig. 5 that the order quantity under the application of blockchain technology is negatively correlated with the cost of blockchain technology, indicating that the lower the cost of blockchain, the higher the order quantity of retail e-commerce to agricultural products. When the blockchain cost $c_b < 10$, the order quantity of retail e-commerce with the application of blockchain technology is greater than that without the application of blockchain technology, it means $q_b^* > q^{\lambda *}$.

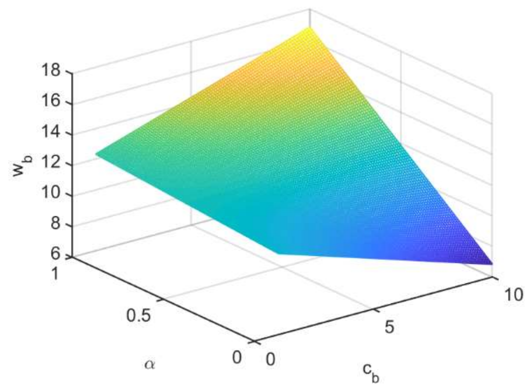

Fig. 6 Relationship between block chain unit cost, cost sharing coefficient and wholesale price

As can be seen from Fig. 6, with the increase of block chain cost sharing coefficient α and block chain cost threshold c_b, the unit wholesale price of agricultural products provided by suppliers increases accordingly. As can be seen from the figure, when the blockchain cost threshold and blockchain cost sharing coefficient reach the maximum, the supplier's wholesale price reaches the highest point.

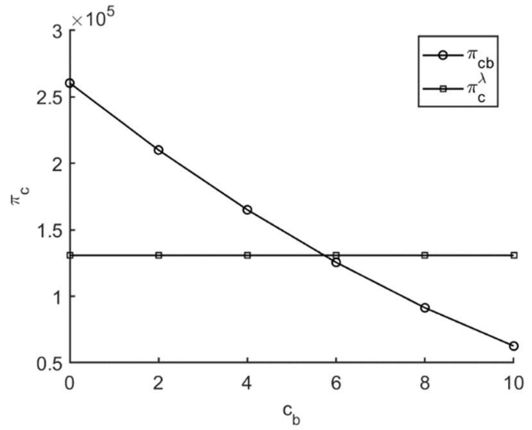

Fig. 7 The relationship between block chain unit cost and supply chain profit

Under the same assumption, according to Fig. 7, the profits of the supply chain are different before and after the application of blockchain technology. The smaller the unit cost of blockchain technology application, the higher the total profit of the supply chain under blockchain technology application. As can be seen from the variation trend of supply chain profit under the application of blockchain technology, when $c_b < 5.72$, the total profit of supply chain under the application of blockchain technology is greater than the overall profit of supply chain under the misreporting behavior, that is $\pi_{cb}^* > \pi_c^{\lambda*}$; on the contrary, when $c_b > 5.72$,Proposition 3 can be proved that the total profit of the supply chain under the application of blockchain technology is less than the total profit of the supply chain under the misreporting behavior, i.e. $\pi_{cb}^* < \pi_c^{\lambda*}$.

5. Conclusion

This chapter considers the by a supplier and a retail electricity constitute the agricultural products supply chain, for the supplier to lie about freshness, research constructs the freshness information symmetry and freshness and block chain under asymmetric information technology application of electrical business decision model of supply chain of agricultural products, at the same time, considering the influence of block chain technology application for the market demand. It is proved that the freshness information asymmetry caused by suppliers' misreporting behavior has a significant impact on the profits of all members of the supply chain. An example is given to analyze the impact of the investment cost threshold of blockchain technology on the ordering decisions and pricing of all members of the agricultural supply chain.

The specific research conclusions are as follows:

(1) suppliers can obtain more profits by concealing the freshness information, and at the same time damage the profits of retail e-commerce to a certain extent, thus failing to realize supply chain coordination.

(2) Block chain technology application unit cost threshold has a significant impact on the price of agricultural products in the supply chain, the profits of each member and the overall profits of the supply chain.

The higher the block chain technology application unit cost threshold, the higher the wholesale price and online sales price. The smaller the unit cost of blockchain technology application, the higher the profit of each member of the supply chain and the overall profit of the supply chain under blockchain technology application.

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