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Research Article

Evolutionary Game Analysis of Standardized Production of Agricultural Products Embedded in Blockchain

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By embedding blockchain technology into the process of standardized production of agricultural products, we use the characteristics of blockchain such as tamper-proof, decentralization, and consensus mechanism to solve the trust problem, responsibility problem, and quality problem in the process of standardized production of agricultural products. These three subjects in the process of standardized production of agricultural products are analysed, and the three-party game model among agricultural producers, government, and consumers is constructed with the help of the evolutionary game method, and the influence of each subject in different strategies is analysed, and the inference results are simulated and experimented with MATLAB 2016 software. The results show that the standardized production of agricultural products embedded in blockchain needs to meet three basic conditions: agricultural producers need to ensure that the sum of production costs and penalties for noncompliance following technological innovation using blockchain is less than the sum of production costs and penalties for noncompliance for traditional agricultural products; the difference value between strict and loose government regulation needs to be smaller than the amount of penalty for violation of standardized production of agricultural products embedded in blockchain; the cost of whistleblowing for consumers needs to be less than the number of penalties incurred for production violations when agricultural producers choose standardized production of agricultural products embedded in blockchain. It is also found that the violation ratio of agricultural producers, the social welfare of strict government regulation, and the whistleblowing benefit of consumers are the key factors affecting the standardized production of agricultural products, and the analysis of the influence of the key factors points to the direction for promoting the standardized production of agricultural products.

1. Introduction

As a large producer of agricultural products in China, the production of agricultural products needs to meet the basic quantity demand, but also to ensure quality and safety, the standardized production of agricultural products has become one of the important means. In 2021, the Central Committee of the Party issued the Central Document No. 1 proposed to further promote agricultural restructuring, promote the cultivation of varieties, quality improvement, brand building, and standardized production. In 2021, the Central Agricultural Work Conference General Secretary, Xi Jinping, also pointed out that the key core technologies of agriculture should be promoted and standardized production of agricultural products should be promoted. In order to thoroughly implement the spirit of the Central Conference on Agricultural Work and the No. 1 Central Document of 2021, the Ministry of Agriculture and Rural Affairs of China implemented the action of "Three Products and One Standard" in agricultural production to promote the standardized production of agricultural products and issued the Implementation Plan of the Action of "Three Products and One Standard" in Agricultural production.

The standardization of agricultural products is the basis for the development of modern agriculture, and the standardization of advantageous agricultural products is an important symbol of modern agriculture, and the combination of the promotion of applicable technologies for agricultural production and the implementation of standardization is an important way to improve the quality and efficiency of agricultural production. Based on the analysis of traditional agricultural production problems, this paper embeds blockchain technology to reconstruct the production process of agricultural products, making the production process of agricultural products more open and transparent, reducing the proportion of irregularities in agricultural production, and promoting the advancement of the standardization process of agricultural products. At the same time, the three main bodies of the standardized production of agricultural products are analysed, and reasonable suggestions are put forward.

2. Literature Review

A review of the relevant literature reveals that many scholars at home and abroad have researched standardized production of agricultural products and blockchain technology as follows.

The research on standardized production of agricultural products is mainly carried out in terms of relationship with modernized agricultural production, the influence of external factors, and the improvement of the quality of agricultural products. Standardized production and modernized agricultural production are closely related, and Cheng et al. proposed to accelerate the construction of agricultural products standardization system adapted to the Internet era, use information technology, and establish a traceability system for the whole process of production, processing, and marketing of agricultural products [1]. Yin et al. proposed that standardized production of agricultural products should be based on agricultural practices, scientific research results, advanced technologies, and sound standardized processes and measurement standards for the production of agricultural products [2]. Through further research, it was found that standardized production can be influenced by various external factors, and Wang et al. pointed out that farmers' participation attitudes, subjective norms, and perceived behavioural control can significantly increase their willingness to participate in the construction of standardized farms, and the total and direct effects of participation attitudes on farmers' willingness to participate are the largest [3]. Ma and Huo suggested that the government should focus on cultivating the market for standardized products, strengthening the regulation of market behaviour, emphasizing the propagation of standardized cognition, and promoting moderate-scale operation [4], and Li suggested that government departments need to guide agricultural enterprises to standardize production so that they can see the benefits of standardized production and the losses of noncompliant production [5]. Scholars also found that standardized production of agricultural products can effectively promote the quality of agricultural products. Li and Zhong proposed that the way out for the quality improvement of agricultural products is to implement standardized production and build regional brands of agricultural products [6]. Geng and Li proposed that to fundamentally implement the standardization of agricultural products, the quality of agricultural products should be guaranteed, productivity should be improved, and the standardized production model should be selected according to local conditions [7]. Fan and Pan proposed that standardized production of large-scale agricultural products can promote the implementation of technical standards for agricultural production, farm operation specifications, and production management standards in the production of agricultural products and can ensure the quality and safety of the whole process of preproduction, production, and postproduction of agricultural products [8].

Scholars have made many useful studies on standardized production of agricultural products, but they mostly focus on the macroscopic analysis of standardized production and are less involved in the process of standardized production of agricultural products and the reduction of violation ratio of agricultural producers, while new technologies such as blockchain are less used in the process of standardized production of agricultural products.

The research on blockchain technology is mainly carried out from three aspects: the relationship with the production process of agricultural products, the advantages of the blockchain traceability system, and the blockchain and trust mechanism. Scholars found that blockchain has strong applicability in the production of agricultural products, and Liu et al. argued that blockchain technology has features such as information sharing, data authenticity, security, information, credential traceability, and smart contracts, which have multiple coupling with the demand of agricultural products circulation and help to solve the pain points in the circulation of agricultural products [9], and Kamilaris et al. proposed that blockchain is a promising supply chain of agricultural products information transparency technology that can be well applied in various food and agriculture-related issues [10]. Scholars have found that the traceability system established by blockchain has many advantages. Wang et al. proposed that the workflow of the agricultural supply chain can be tracked by blockchain technology to achieve traceability and sharing of the supply chain [11]. Cui et al. proposed blockchain technology to build a traceability-trust system for organic agriculture, which helps to break information asymmetry, rebuild the trust relationship between production and consumers, and thus effectively solve food quality and safety problems [12]. Shahbazi and Byun proposed a blockchain machine learning-based food traceability system, which combines new extensions of blockchain, machine learning technology, and a shelf-life-based management system based on a fuzzy logic traceability system for perishable foods [13]. Behnke and Janssen found through their study that blockchain technology can be used in supply chains for traceability of goods and also for creating transparency in the supply of goods. Scholars also found that blockchain can effectively address trust issues [14]. Saberi et al. showed through their study that there is a strong relationship between trust and blockchain technology [15]. Peck identified trust as the main driver for the application of blockchain technology [16]. Dubey et al. proposed that blockchain technology affects rapid trust in the context of humanitarian logistics [17]. Wang found that through the joint participation and real-time maintenance of blockchain nodes, the timely sharing of emergency material donation information and the openness and transparency of material destination can be achieved, which can solve the social trust problem caused by information asymmetry and lay the foundation for the formation of a new governance pattern of "common construction, common governance, and sharing" [18]. Scholars have made many valuable types of research on blockchain technology, but they are mostly focused on solving the quality problems of agricultural products and less involved in applying it to the standardized production of agricultural products.

Moreover, in terms of research methodology, the problem of standardized agricultural production involves an iterative game between the enterprises, government, and consumers, which is different from the traditional social dilemma game, such as the prisoner's dilemma game (PD), where natural selection favours defection and the average population gain which is lower than during when everyone cooperates, resulting in a social dilemma which is characterized by a Nash equilibrium in which all participants are defectors although the number of cooperates is Pareto which is the most efficient one. Also, additional scenarios are identified to avoid the inevitability of social collapse embodied in well-mixed PD. One such scenario is the chicken game (CH) (also the snowdrift game (SD) or the hawk-dove game (HD)), in which mutually betraying individuals is inferior to cooperating-betraying pairs. Thus, CH allows for a stable coexistence of cooperators and defectors in a well-mixed population. The stage hunt game (SH), together with PD and CH, constitutes the standard trio of the most studied social dilemmas, providing more support for cooperative individuals in the sense that the benefits of cooperation outweigh the benefits of exploitation or deception [19–22]. These aforementioned social dilemma problems are analysed in the classical game theory framework, where cooperation is impossible to achieve. In particular, even if the game is repeated a finite number of times (in reality, repeated games cannot be played an infinite number of times), cooperation is unlikely to emerge using the reverse recursive approach. However, cooperation in finite and many repetitive games is prevalent in the real world and in various behavioural experiments [23]. This suggests that real individuals do not behave according to the assumptions made in classical game theory. When the outcome of an individual's choice of a particular strategy depends not only on his own strategic choice but also on the strategic choice of others, the final situation is much more complex than the behaviour predicted by the game under perfect rationality. Therefore, to explain the phenomenon of spontaneous cooperation in selfish groups in real society, we need to break the assumption of perfect rationality, and the traditional game analysis method is based on the analysis of rational reasoning, which cannot reflect the learning process of participants. Therefore, the traditional static analysis framework is powerless to analyse the game problems of finite rational participants. The evolutionary game theory takes the group as the object and finite rationality as the basis, and the game analysis under finite rationality is a new dynamic analysis framework that includes participants' learning and strategy adjustment process. Let the game players form a group, and through the iterative game of random pairing among members, the results of the game are mapped into individual adaptations. This analytical framework is very similar to that of biological evolutionary theory, which is based on the Darwinian idea of natural selection. Moreover, there are similarities between human behaviour and the behaviour of other organisms; for example, human beings will generally be triggered by intuition when encountering complex problems and will imitate the behaviour of successful individuals; human competitive and cooperative behaviour is also very similar to that of the animal world. Therefore, analysing human behaviour by drawing on the methods used to study the mechanisms of trait evolution and stability in biological populations is an effective way to draw on analogical research ideas and methods. More importantly, the analysis method of drawing on biological evolutionary theory and biological behaviour laws can also simulate the dynamic realization process of game equilibrium solutions. The standardized production of agricultural products involves an iterative game between enterprises, government, and consumers, which applies to the analysis of evolutionary game theory [24, 25]. It is also an asymmetric game, i.e., a type of game in which the players do not share the benefits equally in the game process [26], while according to Ma et al., asymmetric games are favourable for the development of cooperation, and the higher the degree of asymmetry, the higher the level of cooperation [27].

In summary, to solve the problem of standardization of agricultural products, this paper tries to embed blockchain in the production process of agricultural products, use the characteristics of blockchain such as nontampering, decentralization, and consensus mechanism to solve the trust problem, responsibility problem, and quality problem in the process of standardized production of agricultural products; meanwhile, use the evolutionary game model to build a three-party game model among agricultural product producers, government, and consumers, to analyse the influence between each subject in different strategies, and to provide suggestions for the technological innovation of enterprises, the implementation of government policies, and the participation of consumers in regulation.

3. The Application Value of Blockchain in the Standardized Production of Agricultural Products

By summarizing the views of relevant scholars, we found that there are many problems in traditional agricultural production, and blockchain can effectively regulate the production process of agricultural products and promote standardized production of agricultural products.

3.1. Applicability of Blockchain to Solve the Problem of Standardized Production of Agricultural Products. There are many problems with traditional agricultural production. Among them, the most important problems include trust, responsibility, and quality. First of all, in the trust problem, during the process of traditional agricultural production, the information of production upstream and production downstream is not open and transparent, which leads to information asymmetry between the two sides, thus making the two sides have a crisis of trust. Secondly, in the problem of responsibility, in the process of traditional agricultural production, there are often unclear responsibilities, and each subject can shirk their responsibilities to each other, resulting in inefficiency in the process of agricultural production. Finally, the quality problem is that the traditional agricultural production process often does not need to report the relevant data, and the information is not public, which leads to people have doubts about the quality of products, and producers often breed the psychology of illegal production, which also makes the quality of products greatly reduced.

Blockchain can effectively solve these problems arising from traditional agricultural production. Firstly, blockchain is decentralized and is a distributed ledger, so the data are no longer concentrated in a central database, which guarantees the openness and transparency of data and information symmetry, and secondly, if blockchain is introduced, the person in charge of each part will pack the data of the relevant part into blocks and then upload them to the chain, which makes the person in charge of each part traceable, and it does not create a situation of shifting responsibilities. Finally, the introduction of blockchain can collect and upload data on the production environment and materials of agricultural products, which can ensure the quality of agricultural products. Therefore, the introduction of blockchain can be a good solution to the pain-point problem of traditional agricultural production.

3.2. Blockchain Reconfigures the Standardized Production Process of Agricultural Products. Blockchain is a distributed ledger system in the form of a decentralized database in a peer-to-peer network, which consists of one block with a timestamp. The block header mainly contains the Hash value of the previous block, the Hash value of the block body, the current time, and other important information, while the "Hash" value means that the computer can calculate a set of characteristic values of the same length for any content. The Hash value of blockchain is 256 bits, which means that no matter what the original content is, the final binary number of 256 bits can be derived, which ensures that the Hash value must be different if the original content is different. By concatenating the Hash, each block can be concatenated into a chain, and the blockchain connection schematic is shown in Figure 1.

At the same time, blockchain also features decentralization, consensus mechanism, anonymity, and non-tampering. The introduction of blockchain technology into the production process of agricultural products can effectively track product information and guarantee product quality, thus ensuring consumer safety. The production process of agricultural products mainly contains planting, storage, processing, logistics, sales, and consumers' purchase. The information on planting, storage, processing, and logistics can be packaged into blocks and then uploaded to the blockchain, and then the supermarkets can put the traceability code on the package for sale, and finally, when consumers buy, they can scan the traceability codes to view the information of the whole production process to ensure that the information is open and transparent, which can also ensures product quality. See Figure 2 for the schematic diagram of standardized production of agricultural products embedded in blockchain.

3.3. The Implementation Process of Standardized Production of Agricultural Products Embedded in Blockchain. In the process of standardized production, three main subjects are involved: agricultural producers, government, and consumers, and the three are inextricably linked to each other. Agricultural producers need to be tested by the government, the government can regulate agricultural producers, agricultural producers will sell agricultural products to consumers, and consumers can report the illegal products of agricultural producers to the government; the government's regulation is to protect the interests of consumers, and consumers can also report the current loose regulation of the government to the higher-level governments; the relationship between the standardized production entities of agricultural products is shown in Figure 3.

At the same time, to achieve standardized production, each subject needs to complete their respective tasks. The first is the agricultural producers. Through the blockchain embedding technology proposed above, the quality of agricultural production can be effectively improved and the proportion of production of offending products can be reduced. The second is the government. The government also needs to strengthen supervision in this production process, strengthen supervision of agricultural producers, and do a good job in macroeconomic regulation, control measures and public service mechanisms to ensure the reasonable and effective operation of various departments. As a third-party supervision mechanism, consumers should actively prosecute the corresponding violations, strengthen the awareness of standardization, consciously resist bad production, and actively promote the standardization of agricultural products to the market.

4. Blockchain-Embedded Game Model Construction for Standardized Production of Agricultural Products

4.1. Model Assumptions. In this paper, we assume three-game subjects: agricultural producers, government, and consumers, who are all finite rational. At the beginning of the game, the three players are not optimal and need to reach a stable state through continuous adjustment. Agricultural producers have two strategic choices: one is to dare to carry out technological innovation and introduce blockchain technology for standardized production of agricultural products; that is, to introduce blockchain technology into the production process of agricultural products and carry out all-round traceability of the production process of agricultural products; the other is not to carry out

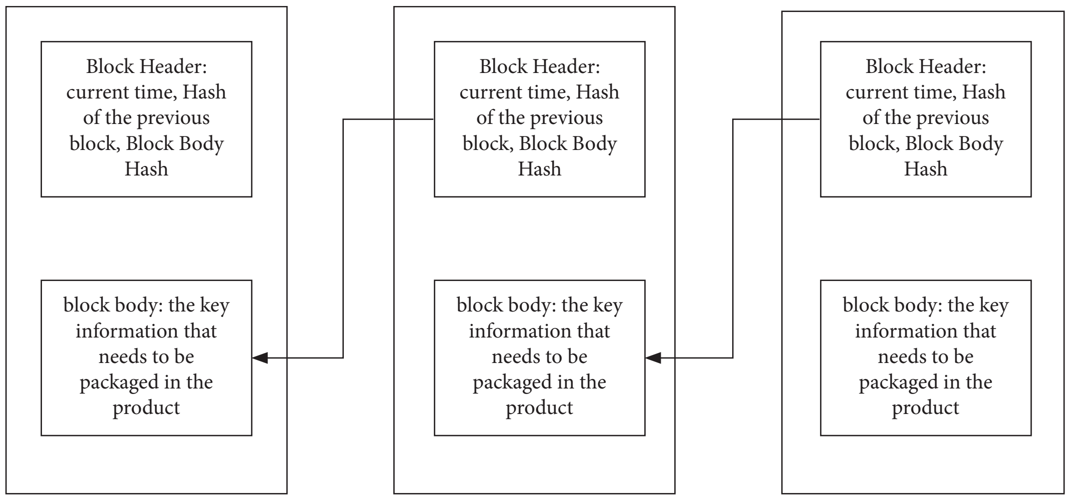


Figure 1: Block connection schematic.

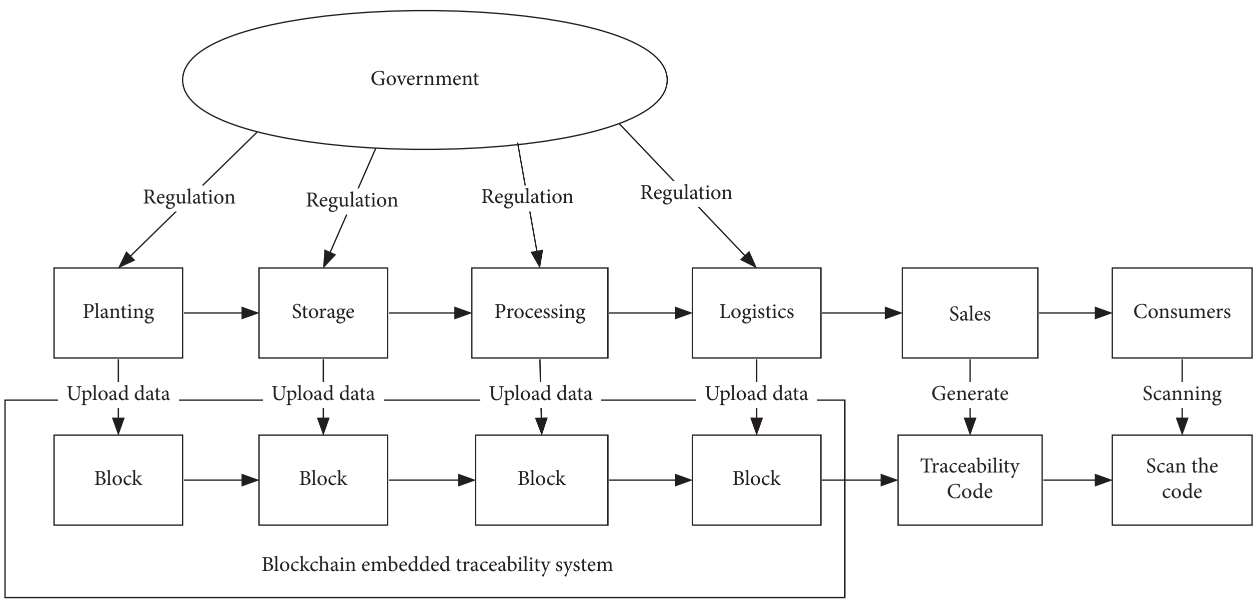


Figure 2: Standardized production of agricultural products embedded in blockchain.

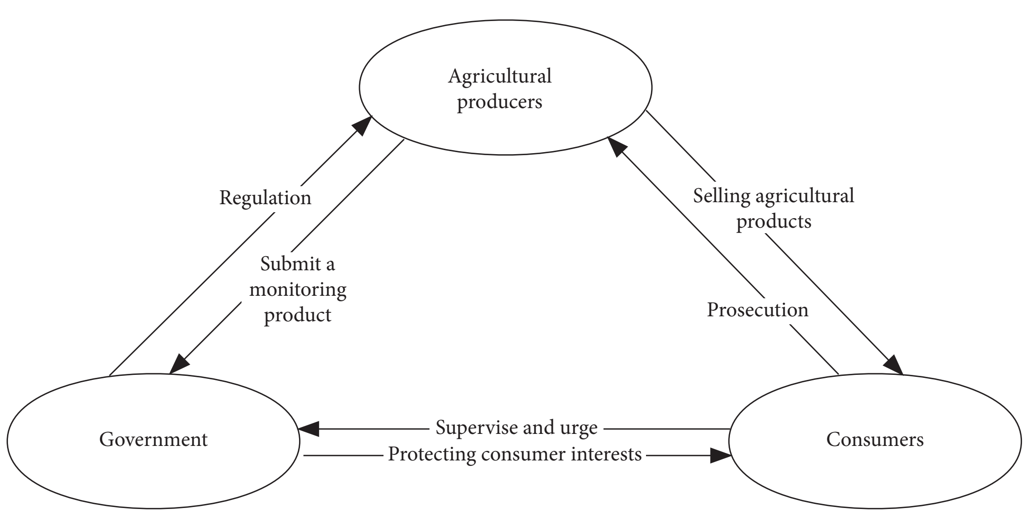


Figure 3: Agricultural products standardized production body relationship map.

technological innovation and adopt the traditional production method, with data recording and uploading handed over to the person in charge for manual processing. The government has two choices: one is strict regulation, such as actively investigating the market condition of agricultural products and actively carrying out a quality inspection of the production process of agricultural products, and the other is loose regulation; that is, the government is indifferent to the market and rarely carries out research and quality inspection. Consumers also have two choices: one is to be treated with the high requirement, i.e., to actively report on shoddy products by agricultural producers and to expose government inaction. The second is a low requirement of treatment; that is, they tolerate the purchase of substandard products and do not choose to speak out, condoning corporate violations and loose government regulation.

Hypothesis 1. Agricultural producers as participant 1, government as participant 2, and consumers as participant 3, and assume that all three participants are finitely rational.

Hypothesis 2. The strategy choice space of agricultural producers is $\alpha = (\alpha_1, \alpha_2) =$ (traditional agricultural production, standardized production of agricultural products embedded in blockchain), and the strategy choice space of government is $\beta = (\beta_1, \beta_2) =$ (strict regulation, loose regulation), and the strategy choice space of consumers is $\gamma = (\gamma_1, \gamma_2) =$ (high requirement, low requirement). Agricultural producers choose traditional agricultural production with probability x, the government chooses strict regulation with probability y, consumers choose high requirement for product quality, and government regulation with probability z.

Hypothesis 3. The normal revenue of agricultural producers is W. The cost required when choosing traditional agricultural production is C_1, and the cost required when choosing standardized production of agricultural products embedded in blockchain is C_2 ($C_2 > C_1$); the cost required when the government strictly regulates is C_3, and the cost required when government loosely regulates is C_4; the fixed cost required for consumers to purchase traditional agricultural products is C_5, and the fixed cost for consumers to purchase standardized agricultural products embedded in blockchain is C_6.

Hypothesis 4. The percentage of violations of traditional agricultural production found by government sampling or consumers is K_1, the percentage of violations of standardized production of agricultural products embedded in blockchain found by government sampling or consumers is K_2 ($K_2 > K_1$), the government will penalize producers of agricultural products found to be produced in violation of the law with a penalty of R, and the severity of punishment imposed by the government on agricultural products producers for violations of production is P.

Hypothesis 5. The fixed benefit obtained from government regulation is S. When the government strictly regulates, the quality of production of agricultural producers will improve and therefore will be rewarded by higher-level governments is F_1, and when the government opts for loose regulation, if consumers report, the government will be punished by the higher-level governments, and the amount of punishment is F_2.

Hypothesis 6. Consumers can report to the government that the product of the agricultural producers is substandard, and at this time, the consumer will receive compensation from the agricultural producers, and the amount of compensation is Q_1; the consumer can also report to the higher-level governments that the government's regulation is too loose, and then at this time the consumer will receive the benefit provided by the higher-level governments which is Q_2, and the cost required by the consumer to report the agricultural producers and the government is C_7.

The model parameters are set in Table 1.

4.2. Model Building. Based on the above assumptions, this paper constructed a mixed strategy model, as shown in Table 2.

4.2.1. The Evolution Process of Agricultural Producers

$$
\begin{aligned}
Ua_1 &= y\left[z\left(W - C_1 - K_1R\right) + (1-z)\left(W - C_1 - K_1R\right)\right] + (1-y)\left[z\left(W - C_1 - K_1R\right) + (1-z)\left(W - C_1\right)\right] \\
&= W - C_1 + K_1PR(yz - y - z), \\
Ua_2 &= y\left[z\left(W_2 - C_2 - K_2PR\right) + (1-z)\left(W_2 - C_2 - K_2R\right)\right] + (1-y)\left[z\left(W - C_2 - K_2R\right) + (1-z)\left(W - C_2\right)\right] \\
&= W - C_2 + K_2PR(yz - y - z), \\
F(x) &= x\left(Ua_1 - \bar{U}\right) = x(1-x)\left(Ua_1 - Ua_2\right) = x(1-x)\left[C_2 - C_1 + R(yz - y - z)\left(K_1 - K_2\right)\right], \\
\frac{dF(x)}{dx} &= (1-2x)\cdot\left[C_2 - C_1 + PR(yz - y - z)(K1 - K2)\right].
\end{aligned}
\tag{1}
$$

Table 1: Model parameter setting.

Parameter meaning	Symbolic representation
Normal returns for agricultural producers	W
Costs required for the production of traditional agricultural products	C_1
Costs required for standardized production of agricultural products embedded in blockchain	C_2
The proportion of violations of traditional agricultural production detected by government sampling or by consumers	K_1
The proportion of violations of standardized production of agricultural products embedded in blockchain detected by government sampling or by consumers	K_2
Government penalizes agricultural producers with fines for production violations	R
The severity of punishment imposed by the government on agricultural products' producers for violations of production	P
Input cost of strict government regulation	C_3
Input cost of loose government regulation	C_4
Fixed income earned from government regulation	S
Social welfare when government regulation is strict	F_1
Punishment by higher-level governments when the government is loose regulation	F_2
Fixed costs for consumers to purchase traditional agricultural production	C_5
Fixed costs for consumers to purchase standardized agricultural products embedded in blockchain	C_6
Cost to consumers to prosecute produce producers and government	C_7
Proceeds received by consumers for reporting offending produce to the government	Q_1
The benefits gained by consumers who report to higher-level governments for the current loose government regulation	Q_2

Table 2: Mixed strategy model.

Strategy Selection		Consumers High requirement (z)	Consumers Low requirement ($1-z$)
Traditional agricultural production (x)	Strict regulation (y)	$W-C_1-K_1PR$, $S+F_1+K_1PR-C_3$, $K_1Q_1-C_5-C_7$	$W-C_1-K_1PR$, $S+F_1+K_1PR-C_3$, $-C_5$
	Loose regulation ($1-y$)	$W-C_1-K_1PR$, $S+K_1PR-K_1F_2-C_4$, $K_1\ (Q_1+Q_2)-C_5-C_7$	$W-C_1$, $S-C_4$, $-C_5$
Standardized production of agricultural products embedded in blockchain ($1-x$)	Strict regulation (y)	$W-C_2-K_2PR$, $S+F_1+K_2PR-C_3$, $K_2Q_1-C_6-C_7$	$W-C_2-K_2PR$, $S+F_1+K_2PR-C_3$, $-C_6$
	Loose regulation ($1-y$)	$W-C_2-K_2PR$, $S+K_2PR-K_2F_2-C_4$, $K_1\ (Q_1+Q_2)-C_6-C_7$	$W-C_2$, $S-C_4$, $-C_6$

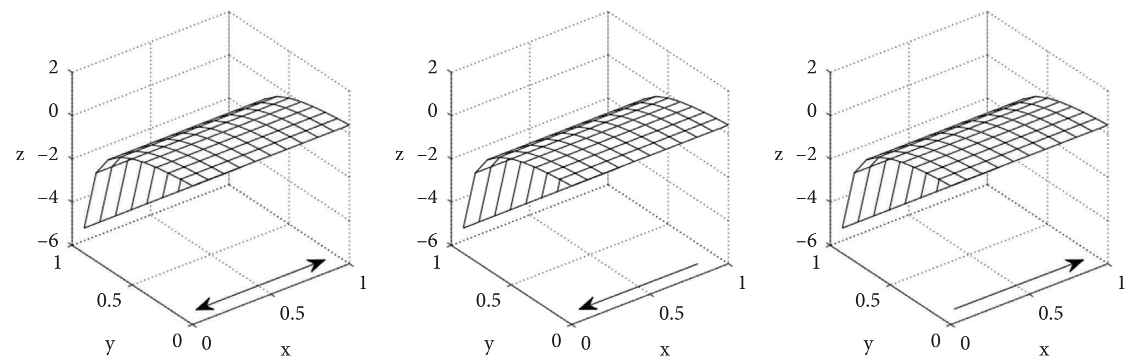
When $z = (C_2 - C_1)/[PR(K_1 - K_2)(1 - y)] - y/(1 - y)$, $F(x) = \mathrm{d}x/\mathrm{d}t = 0$, x takes any value which is the steady state, and both strategies of the agricultural producers are game stable strategies.

When $z > (C_2 - C_1)/[PR(K_1 - K_2)(1 - y)] - y/(1 - y)$, let $F(x) > (\mathrm{d}x/\mathrm{d}t) = 0$, then $x = 0$ and $x = 1$ is the steady state, and at this time, $(\mathrm{d}F(x)/\mathrm{d}x)|_{x=0} < 0$, then $x = 0$ is the equilibrium solution, and agricultural producers choose standardized production of agricultural products embedded in blockchain as the game stable strategy; conversely, $x = 1$ is the equilibrium solution, and agricultural producers choose traditional agricultural production as the game stable strategy.

Thus, the evolutionary process of agricultural producers is shown in Figure 4.

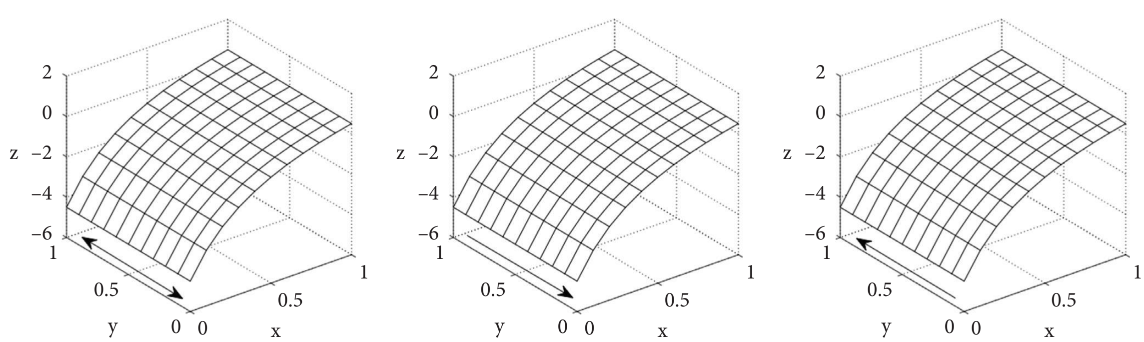
Proposition 1. *The probability of agricultural producers choosing "traditional agricultural production" will decrease with the increase of the government's choice of "strict regulation" and consumers' choice of "high requirement" strategies.*

Proof. The replication dynamic equation of the agricultural producer choosing "traditional agricultural production" is $F(x) = x(Ua1 - \overline{U}) = x(1 - x)(Ua1 - Ua2) = x(1 - x)[C_2 - C_1 + \mathrm{PR}(yz - y - z)(K_1 - K_2)]$, and for x, find the partial derivative $(dF(x)/dx) = (1 - 2x)[C2 - C1 + PR(yz - y - z)(K_1 - K_2)]$, and the response function of the probability x that an agricultural producer chooses for the standardized production of agricultural products which is



$z=\frac{C_2-C_1}{PR\,(K_1-K_2)(1-y)}-\frac{y}{1-y}$ $z>\frac{C_2-C_1}{PR\,(K_1-K_2)(1-y)}-\frac{y}{1-y}$ $z<\frac{C_2-C_1}{PR\,(K_1-K_2)(1-y)}-\frac{y}{1-y}$

FIGURE 4: The evolutionary process of agricultural producers.



$z=\frac{PR}{PR-F_2}-\frac{C_3-C_4-F_1}{[(K_1-K_2)x+K_2](PR-F_2)}$ $z<\frac{PR}{PR-F_2}-\frac{C_3-C_4-F_1}{[(K_1-K_2)x+K_2](PR-F_2)}$ $z>\frac{PR}{PR-F_2}-\frac{C_3-C_4-F_1}{[(K_1-K_2)x+K_2](PR-F_2)}$

FIGURE 5: The evolutionary process of government.

embedded in blockchain with the probability y that the government chooses strict regulation can be obtained as

$$\% x = \begin{cases} 0, & \dfrac{C_2 - C_1}{PR(K_1 - K_2)(1 - z)} - \dfrac{z}{1 - z}, \\[2ex] [0,1], & y = \dfrac{C_2 - C_1}{PR(K_1 - K_2)(1 - z)} - \dfrac{z}{1 - z}, \\[2ex] 1, & y < \dfrac{C_2 - C_1}{PR(K_1 - K_2)(1 - z)} - \dfrac{z}{1 - z}. \end{cases} \tag{2}$$

When $y > (C_2 - C_1)/[\mathrm{PR}(K_1 - K_2)(1 - z)] - z/(1 - z)$, $(z/1 - z)$, $x = 0$ is the evolutionary stability strategy (ESS), which means that when the probability of government choosing "strict regulation" is greater than a certain level, agricultural producers will choose "standardized production of agricultural products embedded in blockchain" to reduce the percentage of violations so that the penalty can be reduced. Conversely, when the probability of the government choosing "strict regulation" is lower than a certain level, agricultural producers will choose "traditional agricultural production" to save costs and thus obtain higher profits.

Similarly, it can be shown that the probability x of agriculture producers choosing "traditional agricultural production" decreases as the probability z of consumers choosing "high requirement" increases, as shown above. □

4.2.2. The Evolution Process of Government

$$\begin{aligned}
Ub_1 &= x[z(S+F_1+K_1PR-C_3)+(1-z)(S+F_1+K_1PR-C_3)]+(1-x)[z(S+F_1+K_2PR-C_3)\\
&\quad +(1-z)(S+F_1+K_1PR-C_3)] = S+F_1-C_3+PR[(K_1-K_2)x+K_2]\\
Ub_2 &= x[z(S+K_1PR-K_1F_2-C_4)+(1-z)(S-C_4)]+(1-x)[z(S+K_2PR-K_2F_2-C_4)+(1-z)(S-C_4)]\\
&= S-C_4+(PR-F_2)[(K_1-K_2)x+K_2]z\\
F(y) &= y(Ub_1-\overline{U}) = y(1-y)(Ub_1-Ub_2) = y(1-y)[C_4-C_3+F_1+[(K_1-K_2)x+K_2][PR-z(PR-F_2)]],\\
\frac{dF(y)}{dy} &= (1-2y)[C_4-C_3+F1+[(K_1-K_2)x+K_2][PR-z(PR-F_2)]].
\end{aligned} \tag{3}$$

When $z = PR/(PR-F_2)-(C_3-\ C_4-F_1)/[[(K_1-K_2)x+F_2](PR-F_2)]$, $F(x) = dy/dt = 0$, y taking any value is a steady state, and both government strategies are game stable strategies.

When $z > PR/PR-F_2-C_3-C_4-F_1/[(K_1-K_2)x+K_2](PR-F_2)$, let $F(y) = F(y) = dy/dt = 0$, then $y=0$ and $y=1$ are steady states; at this time, $dF(y)/dy|_{y=1} < 0$, then $y=1$ is the equilibrium solution, and the government chooses strict regulation as the game stabilization strategy; conversely, $y=0$ is the equilibrium solution, and the government chooses loose regulation as the game stabilization strategy.

Thus, the government evolution process is shown in Figure 5.

Proposition 2. *The probability of the government choosing "strict regulation" will increase with the increase of agriculture producers' choice of "traditional agricultural production" and consumers' choice of "high requirement" strategies.*

Proof. The replicated dynamic equation for the government's choice of "strict regulation" is $F(y) = y(1-y)(Ub_1-Ub_2) = y(1-y)[C_4-C_3+F_1+[(K_1-K_2)x+K_2][PR-z(PR-F_2)]]$, and the partial derivative of y is $dF(y)/dy = (1-2y)[C_4-C_3+F_1+[(K_1-K_2)x+K_2][PR-z(PR-F_2)]]$, which gives the probability of the government's choice of strict regulation y, as a function of the probability of the agricultural producer's choice of traditional agricultural production x, as follows:

$$y = \begin{cases} 0, x < \dfrac{C_3-C_4-F_1}{[\mathrm{PR}-(PR-F_2)z](K_1-K_2)} - \dfrac{K_2}{K_1-K_2} \\[2ex] [0,1], x = \dfrac{C_3-C_4-F_1}{[\mathrm{PR}-(PR-F_2)z](K_1-K_2)} - \dfrac{K_2}{K_1-K_2} \\[2ex] 1, y \dfrac{C_3-C_4-F_1}{[\mathrm{PR}-(PR-F_2)z](K_1-K_2)} - \dfrac{K_2}{K_1-K_2} \end{cases} \tag{4}$$

When $x > (C_3-C_4-F_1)/[PR-(PR-F_2)z](K_1-K_2)-K_1\ /(K_1-K_2)$, $y=1$ is the evolutionary stabilization strategy (ESS), which means that when the probability of agricultural producers choosing "traditional agricultural production" is higher than a certain level, the corresponding violation ratio of agricultural producers will also increase, and then the government will choose "strict regulation" to reduce the percentage of violations. Conversely, when the probability of producers choosing "traditional agricultural production" is below a certain level, the government will choose "loose regulation" because the market is relatively stable and thus will choose loose regulation to save the cost of regulation and thus gain higher profits.

Similarly, the probability y of the government choosing "strict regulation" increases as the probability z of consumers choosing "high requirement" increases, as shown above. □

4.2.3. The Evolution Process of Consumers

$$y = \begin{cases} 0, & x < \dfrac{C_3-C_4-F_1}{[\mathrm{PR}-(\mathrm{PR}-F_2)z](K_1-K_2)} - \dfrac{K_2}{K_1-K_2} \\[2ex] [0,1], & x = \dfrac{C_3-C_4-F_1}{[\mathrm{PR}-(\mathrm{PR}-F_2)z](K_1-K_2)} - \dfrac{K_2}{K_1-K_2} \\[2ex] 1, & x > \dfrac{C_3-C_4-F_1}{[\mathrm{PR}-(\mathrm{PR}-F_2)z](K_1-K_2)} - \dfrac{K_2}{K_1-K_2} \end{cases} \tag{5}$$

When $y = [C_7 - K_1(Q_1 - Q_2)]/[(K_1 - K_2)Q_{1x} + K_2Q_1 - K_1(Q_1 + Q_2)]$, $F(z) = dz/dt = 0$, where z taking any value is a steady state, and both consumer strategies are game stable strategies.

When $y < [C_7 - K_1(Q_1 - Q_2)]/[(K_1 - K_2)Q_{1x} + K_2Q_1 - K_1(Q_1 + Q_2)]$, let $F(z) = dz/dt = 0$, then $z = 0$ and $z = 1$ for the steady state; at this time, $dF(z)/dz|_{z=1} < 0$, then $z = 1$ for the equilibrium solution, then consumers will choose high requirement for the game stable strategy; conversely, $z = 0$ for the equilibrium solution, then consumers will choose low requirement for the game stable strategy.

Thus, the consumer evolutionary process is shown in Figure 6.

Proposition 3. *The probability of consumers choosing "high requirement" will increase with the increase of the government's choice of "loose regulation" and agriculture producers' choice of "traditional agricultural production" strategies.*

Proof. The replication dynamic equation for the consumer's choice of "high requirement" is $F(z) = z(1-z)\,[[(K_1 - K_2)Q_1]xy + [K_2Q_1 - K_1(Q_1 + Q_2)]y + K_1(Q_1 + Q_2) - C_7]$, and the partial derivative of z is $dF(z)/dz = (1-2z)[[(K_1 - K_2)Q_1]xy + [K_2Q_1 - K_1(Q_1 + Q_2)]y + K_1(Q_1 + Q_2) - C_7]$, and we can obtain the response function of the probability x of agricultural producers choosing traditional agricultural production with the probability z of consumers choosing high requirement as

$$z = \begin{cases} 0, & x < \dfrac{C_7 - K_1(Q_1 + Q_2) - [K_2Q_1 - K_1(Q_1 + Q_2)]y}{(K_1 - K_2)Q_1 y}, \\[2ex] [0,1], & x = \dfrac{C_7 - K_1(Q_1 + Q_2) - [K_2Q_1 - K_1(Q_1 + Q_2)]y}{(K_1 - K_2)Q_1 y}, \\[2ex] 1, & x > \dfrac{C_7 - K_1(Q_1 + Q_2) - [K_2Q_1 - K_1(Q_1 + Q_2)]y}{(K_1 - K_2)Q_1 y}. \end{cases} \tag{6}$$

When $x > [C_7 - K_1(Q_1 + Q_2) - [K_2Q_1 - K_1(Q_1 + Q_2)]y]/[(K_1 - K_2)Q_1 y]$, $z = 1$ is the evolutionary stabilization strategy (ESS), which means that when the probability of agricultural producers choosing "traditional agricultural production" is greater than a certain level, consumers will choose "high requirement" to reduce the percentage of violations; conversely, when the probability of choosing "traditional agricultural production" is lower than a certain level, consumers will choose "low requirement" to save the cost of prosecution.

Similarly, it can be shown that the probability z of consumers choosing "high requirement" decreases as the probability y of the government choosing "strict regulation" increases. □

4.3. System Stability Point Equilibrium Analysis. The standard assumption in traditional game theory is that economic agents always make optimal decisions and the economy's norm is equilibrium, which is not in line with reality. Evolutionary game theory assumes that the equilibrium of the economic system is multiple and temporary, and the specific realistic results are path-dependent, and the optimal decision is difficult to achieve, and its emphasis is more on the dynamic process of economic variation. Therefore, we make $F(x) = 0$, $F(y) = 0$, and $F(z) = 0$. In the asymmetric game, if the equilibrium of the game evolution is an evolutionarily stable strategy, it must be a strict Nash equilibrium, and the strict Nash equilibrium is a pure strategy equilibrium. In other words, the mixed strategy equilibrium in asymmetric game dynamics must not be an evolutionary stable equilibrium [28, 29]. Therefore, to discuss the evolutionarily stable strategy for the tripartite role of agricultural producers, government, and consumers, it is only necessary to discuss the stability of these eight points E_1 (0, 0, 0), E_2 (0, 0, 1), E_3 (0, 1, 0), E_4 (0, 1, 1), E_5 (1, 0, 0), E_6 (1, 0, 1), E_7 (1, 1, 0), and E_8 (1, 1, 1) (E_9 (x^*, y^*, z^*) as a mixed strategy is not eligible); according to the method proposed by Friedman, the stability can be analysed by Jacobi matrix. The Jacobi matrix is obtained from the three-way replication dynamic equation as follows:

$$J = \begin{bmatrix} \dfrac{\partial F(x)}{\partial x} & \dfrac{\partial F(x)}{\partial y} & \dfrac{\partial F(x)}{\partial z} \\[2ex] \dfrac{\partial F(y)}{\partial x} & \dfrac{\partial F(y)}{\partial y} & \dfrac{\partial F(y)}{\partial z} \\[2ex] \dfrac{\partial F(z)}{\partial x} & \dfrac{\partial F(z)}{\partial y} & \dfrac{\partial F(z)}{\partial z} \end{bmatrix}. \tag{7}$$

The matrix is specifically derived as follows $dF(x)/dx = (1-2x)(C_2 - C_1 + PR(yz - y - z)(K_1 - K_2))$, $\partial F(x)/\partial y = x(1-x)[C_2 - C_1 + PR(K_1 - K_2)(z-1)]$, $\partial F(x)/\partial z = x(1-x)[C_2 - C_1 + PR(K_1 - K_2)(y-1)]$, $\partial F(y)/\partial x = y(1-y)\,(K_1 - K_2)[PR - z(PR - F_2)]$, $dF(y)/dy = (1-2y)[C_4 - C_3 + F_1 + [(K_1 - K_2)x + K_2][PR - z(PR - F_2)]]$, $\partial F(y)/\partial z = y(1-y)[C_4 - C_3 + F_1 + [(K_1 - K_2)x + K_2]](F_2 - PR)$, $\partial F(z)/\partial x = z(1-z)[(K_1 - K_2)Q_1 y]$, $\partial F(z)/\partial y = z(1-z)[(K_1 - K_2)Q_1 x + K_2Q_1 - K_1(Q_1 + Q_2)]$, $dF(z)/dz = (1-2z)[[(K_1 - K_2)Q_1]xy + [K_2Q_1 - K_1(Q_1 + Q_2)]y + K_1(Q_1 + Q_2) - C_7]$, and the individual equilibrium solutions are brought into the Jacobi matrix to find the corresponding eigenvalues as shown in Table 3 below ($C_2 > C_1$; $K_1 > K_2$).

According to the Lyapunov stability theorem, the sign of the eigenvalues of the Jacobi matrix can be used to determine the stability of the equilibrium point, and when the sign of the eigenvalues is all negative, the equilibrium point is the stable point of the evolutionary game. We summarize the following three general cases by further organizing the above stability conditions.

(1) When $C_2 + PRK_2 < C_1 + PRK_1$, agricultural producers prefer standardized production of agricultural products embedded in blockchain. PRK_1 and PRK_2 represent the number of fines for agricultural producers to choose traditional agricultural production

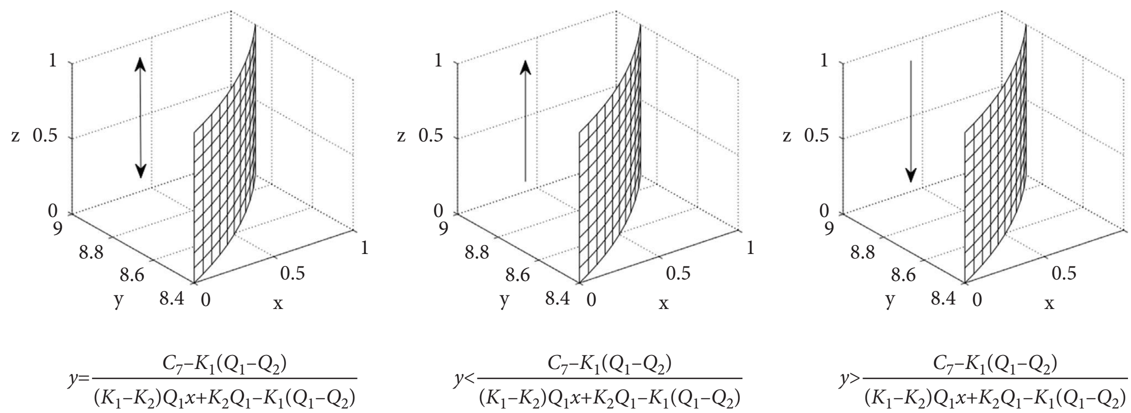


Figure 6: The evolutionary process of consumers.

Table 3: Equilibrium point analysis.

Equilibrium point	Feature root	Stability conditions	Local stability point
E_1 (0, 0, 0)	$C_2 - C_1$; $C_4 - C_3 + F_1 + K_2PR$; $K_1(Q_1 + Q_2) - C_7$	With positive characteristic roots	Instability point
E_2 (0, 0, 1)	$C_2 - C_1 - PR(K_1 - K_2)$; $C_4 - C_3 + F_1 + K_2F_2$; $C_7 - K_1(Q_1 + Q_2)$	$C_2 + PRK_2 < C_1 + PRK_1$; $C_3 - C_4 > F_1 + K_2PR$; $C_7 < K_1(Q_1 + Q_2)$	Progressive stabilization point
E_3 (0, 1, 0)	$C_2 - C_1 - PR(K_1 - K_2)$; $C_3 - C_4 - F_1 - K_2PR$; $K_2Q_1 - C_7$	$C_2 + PRK_2 < C_1 + PRK_1$; $C_3 - C_4 < F_1 + K_2PR$; $C_7 > K_2Q_1$	Progressive stabilization point
E_4 (0, 1, 1)	$C_2 - C_1 - PR(K_1 - K_2)$; $C_3 - C_4 - F_1 - K_2PR$; $C_7 - K_2Q_1$	$C_2 + PRK_2 < C_1 + PRK_1$; $C_3 - C_4 < F_1 + K_2PR$; $C_7 < K_2Q_1$	Progressive stabilization point
E_5 (1, 0, 0)	$C_1 - C_2$; $C_4 - C_3 + F_1 + K_2PR$; $K_1(Q_1 + Q_2) - C_7$	$C_1 < C_2$; $C_3 - C_4 > F_1 + K_2PR$; $C_7 > K_1(Q_1 + Q_2)$	Progressive stabilization point
E_6 (1, 0, 1)	$C_1 - C_2 + PR(K_1 - K_2)$; $C_4 - C_3 + F_1 + K_1F_2$; $C_7 - K_1(Q_1 + Q_2)$	$C_2 + PRK_2 > C_1 + PRK_1$; $C_3 - C_4 > F_1 + K_2F_2$; $C_7 < K_1(Q_1 + Q_2)$	Progressive stabilization point
E_7 (1, 1, 0)	$C_1 - C_2 + PR(K_1 - K_2)$; $C_3 - C_4 - F_1 - K_1PR$; $K_1Q_1 - C_7$	$C_2 + PRK_2 > C_1 + PRK_1$; $C_3 - C_4 < F_1 + K_1PR$; $C_7 > K_1Q_1$	Progressive stabilization point
E_8 (1, 1, 1)	$C_1 - C_2 + PR(K_1 - K_2)$; $C_3 - C_4 - F_1 - K_1PR$; $C_7 - K_1Q_1$	$C_2 + PRK_2 > C_1 + PRK_1$; $C_3 - C_4 < F_1 + K_1PR$; $C_7 < K_1Q_1$	Progressive stabilization point

and standardized production of agricultural products embedded in blockchain, respectively, so $C_1 + PRK_1$ and $C_2 + PRK_2$ represent the potential costs of both inputs, respectively; if $C_2 + PRK_2 < C_1 + PRK_1$ means the input cost of standardized production of agricultural products embedded in blockchain is lower, it indirectly indicates that the use of new technology leads to a significant decrease in the percentage of violations and therefore prefers standardized production of agricultural products embedded in the blockchain.

(2) When $C_3 - C_4 < K_2PR$, the government tends to impose strict regulation. From the above parameter setting, we can get $K_2 < K_1 < (K_1 + K_2)$; thus, we can deduce $C_3 - C_4 < K_2PR < K_1PR < (K_1 + K_2)\ PR$, from which is easy to find that the above stability condition is satisfied. $C_3 - C_4$ represents the difference value between strict regulation and loose regulation, and if this difference value can be smaller than the number of fines for blockchain embedded standardized production of agricultural products, then the government tends to impose strict regulation.

(3) When $C_7 < K_2Q_1$, the consumer tends to have high requirement. Similarly, we can use the known condition of $K_2 < K_1 < (K_1 + K_2)$, so that we can deduce $C_7 < K_2Q_1 < K_1Q_1 < (K_1 + K_2)\ Q_1$, which is easily found to satisfy the above stability condition. When agricultural producers choose the standardized production of agricultural products embedded in blockchain, there may be a small number of

violations, and if the benefits of reporting still outweigh the costs of reporting, consumers will tend to be high requirements.

5. Numerical Analysis of the Three-Party Evolutionary Game

To further verify the correlation between the subjects, MATLAB 2016 was used to simulate and analyse the game results, and the data related to the standardized production of agricultural products embedded in the blockchain were obtained based on the research on the production process of agricultural products in Central Red Group in Harbin, Heilongjiang Province, in August 2021, while the data related to the production of traditional agricultural products in the market were collected from Harbin farmers' market, Querying Harbin government website and questionnaire research consumers to get the range of parameters related to the game subject. The ultimate goal of this paper is to achieve the ideal state that agricultural producers tend to achieve which is standardized production of agricultural products embedded in the blockchain, the government with strict regulation, and having consumers with high requirement, that is, to find the game strategy that tends to be close to the stable point E_4 (0, 1, 1), so this paper sets the following parameters in the reasonable parameter range in Table 4.

5.1. Numerical Analysis of the Stabilization Strategy of the Three-Party Game. Through numerical simulation analysis of the above situation, it can be verified that the three-party game subject can evolve to a stable strategy with t when the constraints are satisfied by agricultural producers, government, and consumers. As shown in Figure 7, the initial values of $x = 0.5$, $y = 0.5$, and $z = 0.5$ are set, and through numerical simulation analysis, under the above conditions, the three-party game subjects finally evolve to the stable state of $x = 0$, $y = 1$, and $z = 1$. At this time, the three-party strategy involves the ideal state of standardized production of agricultural products embedded in blockchain by agricultural producers, strict regulation by the government, and high requirement by consumers.

5.2. Numerical Analysis of Evolutionary Stabilization Strategies for Changing Parameters

5.2.1. Numerical Simulation of Changing K_1 and K_2 on Agricultural Producers' Strategies. Under the condition that other parameters are not changed, the values of the violation ratio K_1 of traditional agricultural production by government sampling or by consumers are taken as 0.5, 0.6, 0.7, and 0.8 respectively for four simulations, and the evolutionary path of agricultural producer's strategy choice is shown in Figure 8. Standardized production of agricultural products embedded in blockchain by the government sampling or by consumers found that the proportion of violations K_2 takes the value of 0.1, 0.2, 0.3, and 0.4 simulations four times, respectively, and the evolutionary path of agricultural producer's strategy choice is shown in Figure 9.

As shown in Figure 8, we can find that as K_1 increases, the faster the agricultural producers tend to 0; that is, the agricultural producers are more willing to adopt the standardized production of agricultural products embedded in blockchain when the violation ratio of traditional production is very high. Similarly, as shown by Figure 9, as K_2 decreases, the faster the agricultural producers tend to 0. This means that if blockchain technology is introduced, the more obvious the effect of reducing the proportion of agricultural production violations is, the more willing agricultural products producers are to carry out technological innovation.

5.2.2. Numerical Simulation of Changing R and F_1 of the Government Strategy. The evolutionary path of the government strategy choice is shown in Figure 10 by taking the values of the government penalty R for production violations as 8, 10, 12, and 14 simulations four times without changing other parameters. The values of social welfare F_1 when the government is strictly regulated are taken as 3, 5, 7, and 9 simulations for four times, and the evolutionary path of the government strategy choice is shown in Figure 11.

As shown in Figure 10, we can find that the penalty fines of the government for production violations do not affect the government regulatory choice and do not play a role in influencing the government to actively regulate; however, as shown in Figure 11, the government tends to 1 significantly faster as F_1 increases, which means that the greater the social welfare generated by strict government regulation, the more it can promote strict government regulation. This also indicates that if the effect of strict regulation is more pronounced, i.e., the more stable the market is under government regulation, the more positively the government is evaluated as well as the better its reputation, and the more the government tends to impose strict regulation.

5.2.3. Numerical Simulation of Consumer Strategy by Changing Q_1 and Q_2. The evolutionary path of the consumer strategy choice is shown in Figure 12, where the benefits of the consumer's reporting to the government about the violation of agricultural products Q_1 are simulated 4 times, 6, 8, 10, and 12 times, respectively. The evolutionary path of consumers' strategy choice is shown in Figure 13 when the benefits gained by consumers who report to higher-level governments for the current loose government regulation Q_2 are taken as 8, 10, 12, and 14 simulations, respectively.

As shown in Figure 12, we can find that the higher the gain obtained by the consumer from reporting the illegal agricultural products to the government, the faster the consumer tends to 1, and the more the consumer tends to ask the producer of the agricultural product with a high requirement standard. Similarly, as shown in Figure 13, the higher the gain from consumers reporting loose government regulation to higher-level governments, the faster the consumers tend to 1. More consumers tend to treat the government with high requirement standards and urge it to impose strict regulation.

Table 4: The parameter setting of the game subject.

Parameters	C_1	C_2	K_1	K_2	P	R	F_1	F_2	C_3	C_4	Q_1	Q_2	C_7
Value	3	4	0.6	0.2	0.6	10	3	4	6	3	6	8	1

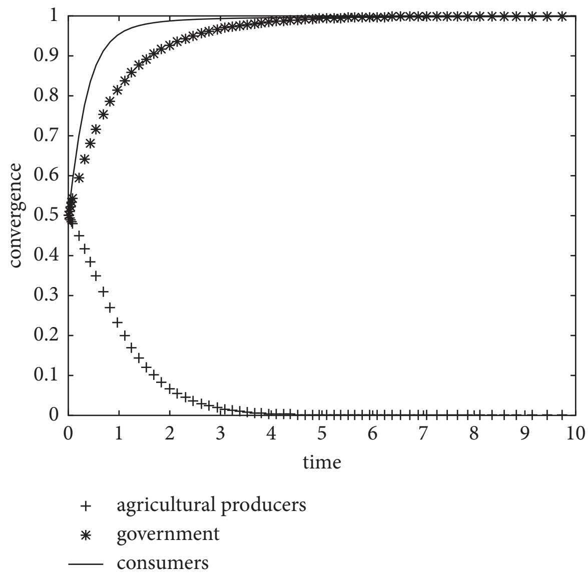


Figure 7: Tripartite evolutionary stabilization strategy diagram.

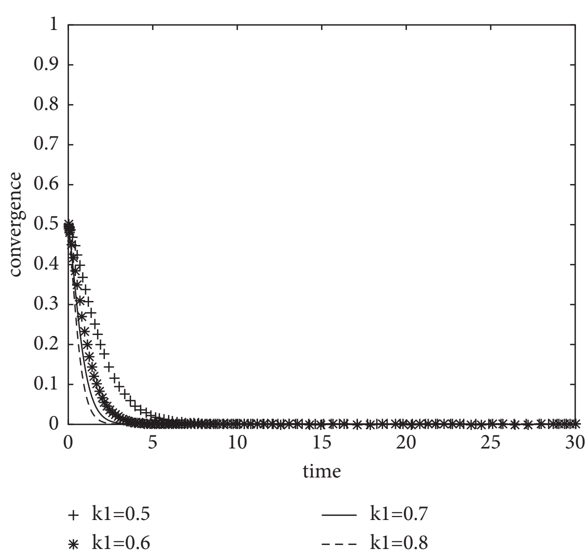


Figure 8: Impact of changing K_1 on agricultural producers.

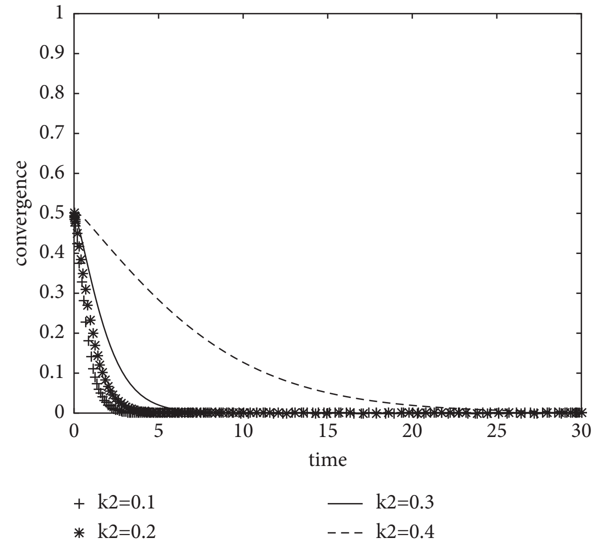


Figure 9: Impact of changing K_2 on agricultural producers.

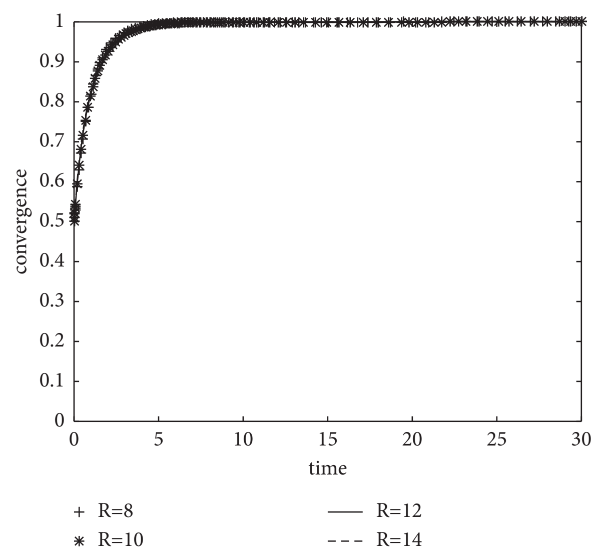


Figure 10: Impact of change R on government.

6. Numerical Analysis of the Three-Party Evolutionary Game

6.1. Conclusion. In this paper, we introduce blockchain technology to optimize the production standard of agricultural products and to build a three-party game model among agricultural producers, government, and consumers from the perspective of enterprise self-effort, government supervision and support, consumer participation and supervision, and to study the behavior of the three subjects with the help of evolutionary game method. The results were simulated using MATLAB, and the following conclusions were drawn:

(1) Encourage agricultural producers to innovate and promote standardized production of agricultural products. Therefore, the agricultural producer should advocate technological innovation in the process of standardized production and boldly introduce blockchain technology to reduce the proportion of irregularities, so that the whole production process of agricultural products can be traced and the information is open and transparent, and at the same time, the proportion of irregularities in production can be reduced, so that agricultural

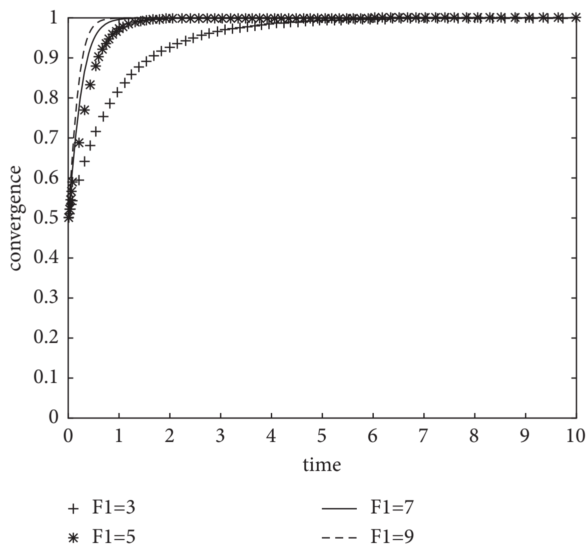


Figure 11: Impact of change F_1 on government.

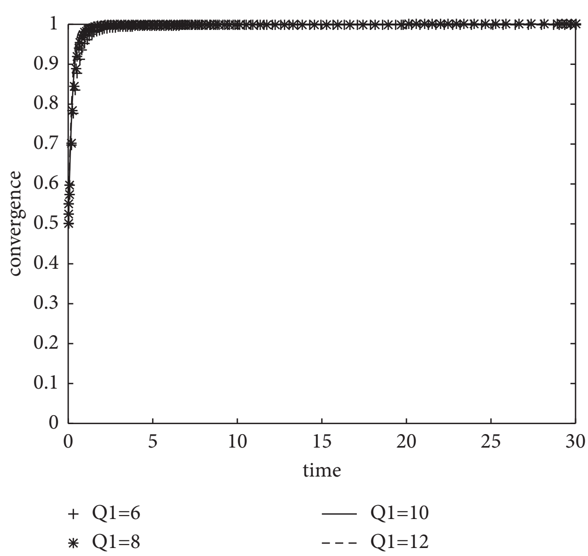


Figure 12: Changing the impact of Q_1 on consumers.

producers can be less punished by the supervisory authorities and can feel more secure about the agricultural products they buy. It can also make consumers feel more secure about the agricultural products they buy. At the same time, the game results show that for agricultural producers to carry out standardized production of agricultural products embedded in the blockchain, they need to meet the stable condition of $C_2 + PRK_2 < C_1 + PRK_1$; that is, agricultural producers need to ensure that the sum of production costs and penalties for noncompliance following technological innovation using blockchain is less than the sum of production costs and penalties for noncompliance for traditional agricultural products, and the percentage of violation of traditional production is very high, and the blockchain

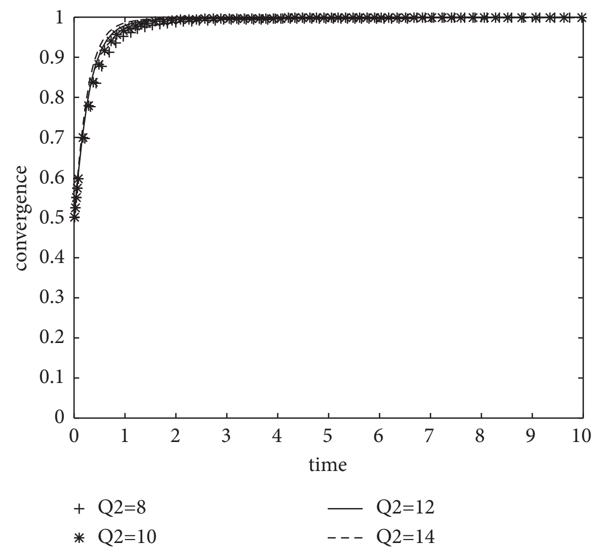


Figure 13: Changing the impact of Q_2 on consumers.

embedded in the standardized production of agricultural products can effectively promote the technical innovation of agricultural producers by significantly reducing the percentage of violations.

(2) The government fulfils its regulatory responsibilities and promotes the process of standardized production. At the same time, it should focus on cultivating consumers' awareness of rights, popularize the concept of standardized production to the public, and let more consumers participate in the process of standardized production to accelerate the standardized production of agricultural products. At the same time, the game results show that to make the government carry out strict regulation needs to meet the stable condition of $C_3 - C_4 < K_2PR$; that is, the difference value between the cost of strict regulation and the cost of lenient regulation should be smaller than the amount of penalty for violation of standardized production of agricultural products embedded in the blockchain, and the penalty fine of the government for violation of production does not affect the government's choice of regulation, but the increase of social welfare generated by strict government regulation can effectively promote strict government regulation, so a better social reputation is more likely to promote government regulatory incentives.

(3) Consumers also have an important role in the standardized production process. On the one hand, consumers can effectively supervise the products of agricultural producers, and if they find illegal products, they are willing to report them. On the other hand, consumers also play a supervisory role in the government, which can effectively urge the government to regulate and better maintain market stability. At the same time, the game results show

that the stability condition of $C_7 < K_2Q_1$ needs to be satisfied to make consumers demanding; that is, the cost of consumers' prosecution needs to be smaller than the penalty amount of reporting agricultural producers' production violations under blockchain embedding, and the increased revenue generated by consumers reporting produced violations by producers and loose government regulation can effectively promote high consumer requirement on agricultural producers and government.

6.2. Policy Recommendations

(1) The government should vigorously advocate the industrial transformation of producers, encourage them to carry out technological innovation, standardize the production process by introducing blockchain and other technologies, and accelerate the promotion of the standardized production process of agricultural products.

(2) The government should strengthen supervision and improve the supervision system. Local governments can establish a reasonable standardized supervision system by combining the regional characteristics and actual situation with the instructions and strategic arrangements of the central government and regularly conducting special inspections of standardized production to agricultural producers.

(3) The government should do a good job of propaganda, strengthen consumers' awareness of standardization, advocate for consumers to actively report producers' irregularities, resist unscrupulous businessmen together, and play the role of consumer supervision.

Data Availability

The data used to support the finding of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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