ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
https://doi.org/10.17559/TV-20220518120528
Original scientific paper

Supervision Timing Simulation Analysis of Community E-commerce Platform Supply Chain Based on Tripartite Game Model

Ziyu LIU, Lixia ZHAO, Changli WU*

Abstract: With the development of network and the popularity of e-commerce, the network service industry has shown strong development potential, and many community e-commerce platforms have emerged as the times require. In order to ensure the profit of the supply chain of community e-commerce platform and supervise whether the suppliers of enterprises and grid station service providers try their best to participate in value co-creation, this paper introduces the delay parameter a of community e-commerce platform, constructs a three-party evolutionary game model of "community e-commerce platform-grid station service provider-supplier", simulates the strategies of each agent with matlab, studies the behaviours of community e-commerce platform under different delay parameters, and concludes that the delay parameter a of community e-commerce platform has a great influence on the timing of community e-commerce platform supervision. Finally, three suggestions are put forward for the supervision of the supply chain of community e-commerce platform: (1) encourage consumers to report; (2) formulate the reward and punishment system for the settled enterprises; (3) formulating a reasonable supervision system.

Keywords: community e-commerce platform; community e-commerce platform supervision; simulation analysis; supervision timing; tripartite game

1 INTRODUCTION

E-commerce is not only Taobao shopping, but is also gradually applied to our daily vegetable purchasing. The supply chain of community e-commerce platform, such as delivery every other day, door-to-door, orange heart optimization, beauty group optimization and grocery shopping, has begun to enter our field of vision. Community e-commerce platform provides convenience for people, but also makes some suppliers' overstocked goods delivered to customers through cooperation with e-commerce platform.

Community-based online store supply chain refers to the relationship between suppliers and consumers based on community-based online store, which integrates all resources in the chain and makes the supply, sorting and distribution links seamlessly. The supply chain of community-based online store is different from that of convenience stores and supermarkets. In supermarket, merchants buy goods from wholesalers, wholesalers distribute them to merchants through logistics, and merchants sell them. However, the supply chain of community-based online store distributes goods provided by suppliers to self-lifting points set by community leaders through grid service providers, and consumers can lift them themselves. Participants in the supply chain of community-based online store include suppliers, community-based online store, Grid station service providers, community leaders and consumers. (1) Suppliers. The suppliers of community-based online store are not only simple wholesalers, but also commodity manufacturers and farmers. Manufacturers and farmers join the platform to become suppliers, and directly supply commodities for the supply chain of community-based online store. This is why many products of community-based online store are cheaper than offline ones. (2) Community-based online store. Community-based online store displays the goods provided by suppliers on the platform, and consumers purchase goods on the platform. (3) Grid station service providers. Grid station service providers are not only the distributors of the supply chain of community e-commerce platform, but also undertake the sorting business of community e-commerce platform and store the goods provided by suppliers. (4) Community leaders. Community leaders are responsible for setting and managing self-raising points and dealing with after-sales problems of consumers. (5) Consumers. Consumers browse and purchase the products of community e-commerce platform, which is the source of supply chain revenue of community-based online store. The functions of each participant in the supply chain of community-based online store are shown in Fig. 1.

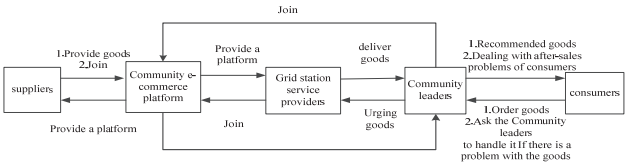


Figure 1 Functional diagram of community e-commerce platform supply chain participants

Some scholars have studied the supervision of e-commerce platform. Wang Xiaoye [1] pointed out that there is an illegal act of "choosing one from the other" in e-commerce platform, which will seriously damage competitors' ability to achieve the lowest scale economy, or prevent new enterprises from entering the market, which will hinder market competition to a great extent. Zhang, M et al. [2] pointed out that in the problem of food safety in online catering, due to the serious dispersion of food safety producers and the weak institutional resources for supervising and implementing safety standards, the government is facing great challenges in ensuring food safety. At the same time, with the rapid development of the online ordering industry, there are many online catering businesses and heavy supervision tasks. As a single subject of food safety supervision, the government has limited technology and ability, and the defects of the "unified" supervision mode have become increasingly prominent. Wu Bin et al. [3] put forward the phenomenon of "killing the mature" of e-commerce platform from the perspective of psychological accounts. By establishing the prospect-benefit perception matrix of e-commerce platform, cost account and price account of government departments, this

paper analyzes the game evolution process and stability strategy between e-commerce platform and government departments. Finally, the factors affecting decision-making behaviour are further verified by numerical simulation technology, and suggestions are given for this phenomenon: consumers should recognize the rights of their citizens to report in time and increase punishment. Zhang Shun et al. [4] analyzed the influencing factors of effective supervision of cross-border e-commerce platform mode by constructing the Logit model, and based on this, gave some suggestions on the realization path of governance mechanism of digital economy platform. Wang Lei et al. [5] studied the trust crisis of e-commerce platform, proposed a consumer-to-business-to-consumer model based on margin policy for e-commerce platform, and gave three modes under margin policy based on two-way game: unit price trading mode, double price trading mode and consumer reporting behaviour mode. Salmina. SV et al. [6] studied the taxation problem of cross-border e-commerce, and put forward a possible way to standardize cross-border electronic commerce's taxation by bringing digital platform into the taxation process and giving full play to it.

In the aspect of solving regulatory problems, some scholars use tripartite evolutionary game to analyze them. In the aspect of environmental quality supervision, Sheng, Jichuanet al. [7] theoretically analyzed the evolution and stability strategies of China's national government, local government and enterprises through tripartite evolution game, discussed the factors affecting the strategies of various stakeholders, and tested the incentive-compatible environmental regulation policies. With regard to the sustainable development of China's e-waste recycling industry, Wang Zheet al. [8] proposed a tripartite evolutionary game model composed of government, recyclers and consumers, determined the system's revenue matrix, and numerically simulated three optimal evolutionary stability strategies for industrial development, and concluded that government supervision should play a leading role in the development of e-waste recycling industry. On the network car platform, Dongping Puet al. [9] supervised the network car platform by establishing a tripartite evolutionary game model. By simulating and studying the evolution path and equilibrium state of the platform, passengers and drivers, it was concluded that reducing reporting costs and increasing rewards could improve the effective supervision of the network car platform. In the collaborative supervision of e-commerce, Bin Wu et al. [10] found that there is no stable equilibrium point in the model through modelling, theoretical derivation and analysis, and concluded that increasing the cooperative income and commission coefficient can encourage the government to adopt supervision strategies, and allowing consumers to participate in supervision can make e-commerce platforms make better decisions. In the aspect of sustainable development of infrastructure projects, Yang K et al. [11] constructed a tripartite evolutionary game model of government, key enterprises and the public, and simulated and analyzed their behaviour strategies at different stages of infrastructure projects and their sensitivity to related influencing factors. It was concluded that the government acted as a leader in the initial stage and gradually evolved into a guardian in the middle and operation stages. In the sustainable development of China's coal industry, Wang Yadong et al. [12] constructed a tripartite evolutionary game model involving the central government, local governments and coal enterprises, and then used it to test the dilemma of overcapacity governance and alternative policies. Xiao Meng [13] focuses on the phenomenon of "big data killing" implied in e-commerce and discusses how to take the government as the lead to coordinately supervise the price discrimination behaviour of e-commerce companies towards loyal customers.

Based on the above literature, it can be seen that there are regulatory problems in e-commerce platform. At present, the supervision of e-commerce platform by scholars only stays on external supervision, while community e-commerce platform also has regulatory problems. However, scholars have not conducted in-depth research on the supervision of community e-commerce platform. In order to improve their own profits, suppliers may not abide by the contract, provide inferior goods or fake and shoddy goods for bad competition, and grid station service providers may delay delivery and do their best, which will lead to a decline in consumers' goodwill, thus leading to a decrease in consumers and sales volume, thus damaging the supply chain revenue of community e-commerce platform. Therefore, it is of great significance to study the supervision of community e-commerce platform. Scholars apply evolutionary game to study the supervision problem, which shows that tripartite game is suitable for studying the supervision problem of enterprises, and it is also suitable for the supervision problem of community e-commerce platform. At the same time, the supply chain of community e-commerce platform meets the characteristics of "incomplete information" and "limited rationality of participants" in evolutionary game, which provides ideal research conditions. Therefore, this paper studies the supervision of community e-commerce platform on settled enterprise suppliers and grid station service providers in supply chain, and the degree of delay in supervision timing of community e-commerce platform will play a key role in the benefits of community e-commerce platform supply chain. Therefore, this paper introduces the delayed supervision parameter A of community e-commerce platform and establishes a tripartite game model of "community e-commerce platform-grid station service provider-supplier". Matlab is used to simulate the dynamic game process and strategy selection of the community e-commerce platform supply chain participating in the main community e-commerce platform, grid station service providers and suppliers. By analyzing the process and results of the tripartite game, it provides reference for the community e-commerce platform to choose the supervision opportunity.

2 METHODOLOGY

2.1 Problem Description

In evolutionary game, all participants are bounded rationality. Through learning, they communicate and coordinate with other participants, and correct existing strategies, so that the game system can reach a balanced and stable state.

As the main body of providing goods, many suppliers start unfair competition due to the expulsion of interests, such as: shoddy goods when providing goods, providing cheap inferior products, even providing non-brand products under the banner of brands, providing good quality goods when signing contracts with community-based online stores and providing product samples, but providing fake and inferior products when officially launching the platform, with high prices; After-sales service is not good for goods that consumers have already purchased. These behaviours of suppliers will cause the community-based online store to lose the consumer groups, thus losing customers, which will reduce the supply chain revenue of the community-based online store.

Grid station service providers connect the community-based online store and suppliers, store the goods provided by suppliers, and distribute the goods to the pick-up points. In order to improve their own profits, some grid station service providers will choose to take orders from multiple distribution points. Due to the limited distribution vehicles and sorters, it will lead to the time delay of grid station service providers' delivery to the site. In addition, grid station service providers need a hygienic environment for storing goods, and need corresponding hygienists to clean up the environment. However, some grid station service providers have unsanitary storage environment in order to save money, which leads to the pollution of goods at storage points, and even more serious, it will cause harm to consumers. These behaviours of grid service providers will make consumers' experience of community-based online store supply chain decline, which will have a great impact on community-based online store, losing a large number of customers, making the sales volume of community-based online store products decline and the supply chain revenue of community-based online store decline.

In the process of participating in the community-based online store supply chain revenue, whether the grid station service providers deliver the goods to the community self-raising point on time (best effort and not best effort), whether the suppliers fulfil their obligations according to the contract signed when joining the community-based online store supply chain, whether they strictly abide by the regulations of the community-based online store, whether the goods are qualified (abide by the contract and not abide by the contract), and whether the community-based online store supervises the suppliers and grid station service providers. Under which choice, the supply chain of community-based online store has a higher profit, which will have an impact on the supply chain of community e-commerce. Therefore, platform enterprise community-based online store and service providers and suppliers who settle in enterprise grid stations can choose different decisions, and the decisions of the three will influence each other. As shown in Fig. 2, it is a tripartite game model composed of community-based online store, grid station service providers and suppliers.

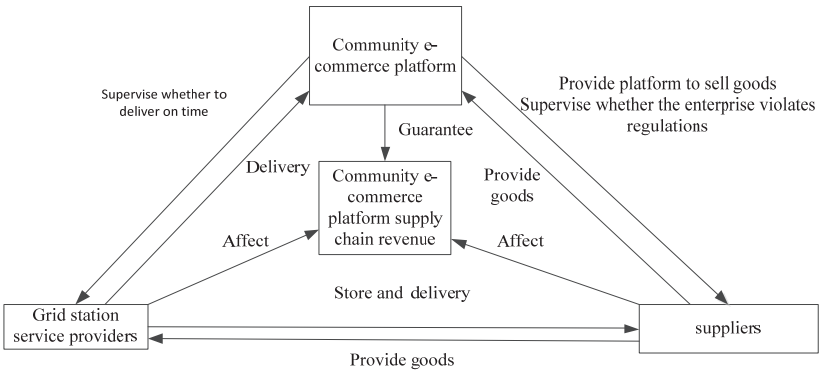


Figure 2 Tripartite game diagram of community e-commerce platform supply chain

2.2 Relevant Assumptions

(1) The subject hypothesis of tripartite game. It is assumed that the actors participating in the tripartite game, community-based online store, grid station service providers and suppliers are all bounded rationality.

(2) Delayed supervision of community-based online store. The degree of delay in the supervision of community-based online store is the key to the supervision of community-based online store. Assuming that "the degree of delay in supervision" is "the revenue of suppliers and grid service providers will be relatively delayed after supervision", the delay degree of community-based online store is expressed by parameter a, and the value interval is (0, 1). The later the supervision of community-based online store is, the larger the value of a is, and the opposite is smaller.

(3) Strategic assumptions of supervision behaviour of community-based online store: supervision and non-supervision. For various reasons, the community-based online store failed to obtain the mistakes of suppliers and grid service providers in time, failed to supervise, or failed to supervise due to inadequate preparation. The supervision probability is x, and the unsupervised probability is $1 - x$. When $x = 1$, it means that the community-based online store must be supervised; $x = 0$ means that the community-based online store must not be supervised.

(4) Suppliers behaviour hypothesis: abiding by contract and not abiding by contract. In order to increase profits, some suppliers' shoddy goods, provide poor quality products, even fake and shoddy products, and even bad competition. In the process of participating in the supply chain revenue of community-based online store, due to the profit-seeking of suppliers, in order to make personal income higher, there is a strategic choice of not abiding by contracts. The probability of abiding by the contract is y, and the probability of not abiding by the contract is $1 - y$. When $y = 1$, it means that the suppliers must abide by the contract; $y = 0$ indicates that the suppliers must not abide

by the contract. When abiding by the contract to ensure the supply chain revenue of the community-based online store, strictly abide by the contract signed with the community-based online store. The goods provided by the suppliers are of good quality, and the suppliers will try their best to carry out preferential activities on the platform to provide maximum benefits for consumers and create more benefits for the community-based online store.

(5) Behaviour assumptions of grid station service providers: best effort and not best effort. In the process of participating in the supply chain revenue of community-based online store, due to the profit-seeking nature of grid station service providers, in order to make personal income higher, there is a strategy choice that does not make every effort. The probability of doing best is z, and the probability of not doing best is $1-z$. When $z=1$, it means that the grid station service providers must do their best; When $z=0$, it means that the grid service providers must not try their best. When the grid station service providers try their best, the grid station service providers will deliver the goods to the leader's pick-up point within the specified time, or even send them to the leader's pick-up point in advance, which can improve the consumer experience and increase the sales volume of the platform. At the same time, the warehouse where the grid station service providers store the suppliers' goods is clean and tidy, and the workers of the grid station service providers have complete relevant health certificates.

(6) Model parameter setting. Under the supervision of community-based online store, the benefits and losses of community-based online store, suppliers and grid service providers with different strategy combinations are different, in order to express the income matrix of each subject and ensure the objectivity of parameter setting as much as possible. The definition of each subject parameter is shown in Tab. 1.

Among them, when a certain subject parameter changes, it will have a direct impact on the decision-making of other subjects, and this decision will indirectly affect the numerical changes of other subject parameters, thus forming the internal relationship among the subjects.

(7) Three-party game income. According to the parameters in Tab. 1, calculate the income matrix of each subject under each strategy set, as shown in Tab. 2.

Table 1 Definition of parameters of each subject

Participants	Parameter	Meaning
Community e-commerce platform	C_{11}	The cost of supervision.
	C_{12}	The cost of no supervision.。
	E_{11}	Loss without supervision.
	E_{12}	Without supervision, grid station service providers will bring losses to the supply chain of community-based online store.
	E_{13}	When supervising, the suppliers bring losses to the supply chain of the community-based online store.
	I_{11}	Revenue from regulation: influence of suppliers on supply chain of community-based online store.
	I_{12}	Revenue from dynamic supervision of supply chain of community-based online store by grid station service providers during supervision.
	a	Delay parameter of community-based online store supervision: the lag degree of revenue relative to suppliers and grid station service providers.
Suppliers	C_{21}	Comply with the contract and try to ensure the cost of the supply chain revenue of the community-based online store.
	E_{21}	When the community-based online store is not supervised, the suppliers abide by the contract and try their best to ensure the loss of the supply chain revenue of the community-based online store.
	E_{22}	When the community-based online store is supervised, the suppliers abide by the contract and try their best to ensure the loss of the supply chain revenue of the community-based online store.
	I_{21}	Revenue from compliance with contracts.
	I_{22}	Try their best to ensure the benefits obtained by grid station service providers in complying with the contract in the supply chain revenue of community-based online store.
	I_{23}	In the process of abiding by the contract, the benefits obtained through the supervision of the community-based online store.
Grid station service providers	C_{31}	Grid station service providers try their best to ensure the cost of supply chain revenue of community-based online store.
	E_{31}	Do not try to guarantee the loss of supply chain revenue of community-based online store.
	E_{32}	The loss caused by the supervision of community-based online store for grid service providers to participate as much as possible.
	I_{31}	Benefits of participating to the best of your ability.
	I_{32}	Gains from supervision of community-based online store.

Table 2 Income matrix of each subject in tripartite game

Policy collection	Community e-commerce platform	Suppliers	Grid station service station
(supervise, observe, best effort)	$(1-a)(I_{11}+I_{12}-C_{11}-E_{13})$	$I_{21}+I_{22}+I_{23}-C_{21}-E_{22}$	$I_{31}+I_{32}-C_{31}-E_{32}$
(supervise, observe ,not best effort)	$(1-a)(I_{11}-C_{11}-E_{13})$	$I_{21}+I_{23}-C_{21}-E_{22}$	$-E_{31}$
(supervise, not observe, best effort)	$(1-a)(I_{12}-C_{11}-E_{13})$	0	$I_{31}+I_{32}-C_{31}-E_{32}$
(supervise, not observe, not best effort)	$-C_{11}-E_{13}$	0	0
(not supervise, observe, best effort)	$-C_{12}-E_{11}-E_{12}$	$I_{21}+I_{22}-C_{21}-E_{21}$	$I_{31}-C_{31}$
(not supervise, observe, not best effort)	$-C_{12}-E_{11}$	$I_{21}-C_{21}-E_{21}$	$-E_{31}$
(not supervise, not observe, best effort)	$-C_{12}-E_{12}$	0	$I_{31}-C_{31}$
(not supervise, not observe, not best effort)	$-C_{12}$	0	0

2.3 RESEARCH MODEL

In the process of tripartite game of community-based online store supply chain, each subject is bounded by rationality, and the dynamic replication equation is constructed to ensure the maximum benefit of community-based online store supply chain, and the strategy is adjusted with the sales volume of community-based online store supply chain, and the equilibrium solution is finally obtained through repeated trial and error learning.

1) Analysis on the evolution of community-based online store strategy. The supervised income of

community-based online store is u_{11}, the expected income without supervision is u_{12}, and the average expected income of community-based online store is u_1, then:

$$u_{11} = (1-a)(yI_{11} + zI_{12}) + [a(y+z-yz)-1] \cdot \cdot (C_{11} + E_{13}) \quad (1)$$

$$u_{12} = -yE_{11} - zE_{12} - C_{12} \quad (2)$$

$$u_1 = xu_{11} + (1-x)u_{12} = x\{(1-x)(yI_{11} + zI_{12}) + + [a(y+z-yz)-1] \cdot (C_{11} + E_{13})\} + + (1-X)(-yE_{11} - zE_{12} - C_{12}) \quad (3)$$

The replication dynamic equation of the community-based online store is:

$$f(x) = \frac{dx}{dt} = x(1-x)\{y[(1-a)I_{11} + a(1-z)(C_{11} + E_{13}) + + E_{11}] + (1-a)zI_{12} + (az-1)(C_{11} + E_{13}) + zE_{12} + C_{12}\} \quad (4)$$

When $y = \frac{(1-az)(C_{11}+E_{13}) - (1-a)zI_{12} - zE_{12} - C_{12}}{(1-a)I_{11} + a(1-z)(C_{11}+E_{13}) + E_{11}}$, make $f(x) = \frac{dx}{dt} = 0$, any value of x is stable, and the two strategies of community-based online store are game stable strategies;

When $y > \frac{(1-az)(C_{11}+E_{13}) - (1-a)zI_{12} - zE_{12} - C_{12}}{(1-a)I_{11} + a(1-z)(C_{11}+E_{13}) + E_{11}}$, make $f(x) = \frac{dx}{dt} = 0$, then $x = 0$ and $x = 1$ are stable; under the circumstances, $\left.\frac{df(x)}{dx}\right|_{x=1} < 0, \left.\frac{df(x)}{dx}\right|_{x=0} > 0$, then $x = 1$, is the equilibrium solution, community-based online store chooses supervision strategy as stable strategy; on the contrary, $x = 0$ is an equilibrium solution, and the unsupervised strategy of community-based online store is a game stable strategy. The evolution process of community-based online store strategy is shown in Fig. 3.

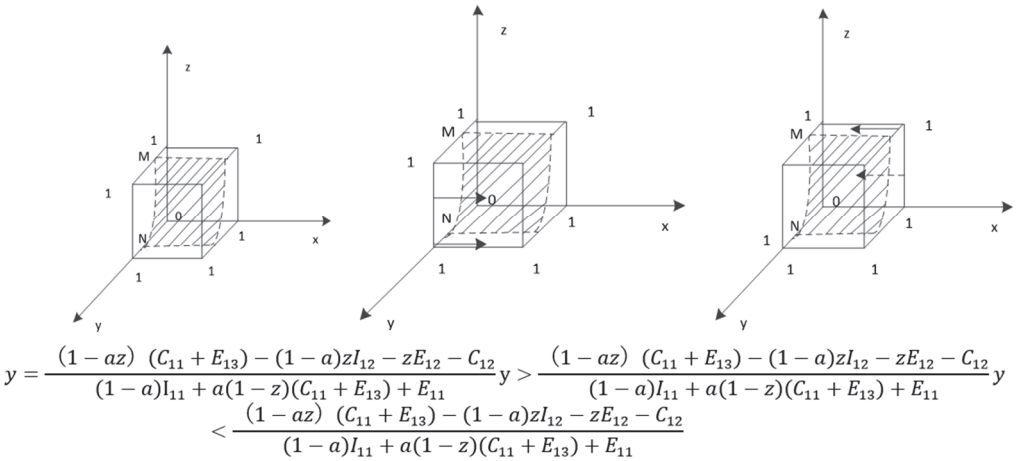


Figure 3 Evolution diagram of community e-commerce platform strategy

2) Evolution analysis of suppliers' strategy. The expected return of the suppliers for compliance with the contract is u_{21}, the expected return for non-compliance with the contract is u_{22}, and the average return is u_2, then:

$$u_{21} = x(I_{23} + E_{21} - E_{22}) + zI_{22} + I_{21} - C_{21} - E_{21}; \quad u_{22} = 0 \quad (5)$$

$$u_2 = yu_{21} + (1-y)u_{22} = y[x(I_{23} + E_{21} - E_{22}) + + zI_{22} + I_{21} - C_{21} - E_{21}] \quad (6)$$

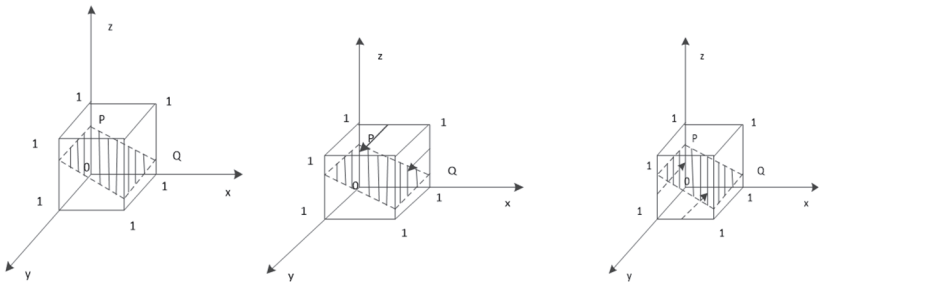
The suppliers' replication dynamic equation is:

$$f(y) = \frac{dy}{dt} = y(1-y)[x(I_{23} + E_{21} - E_{22}) + zI_{22} + + I_{21} - C_{21} - E_{21}] \quad (7)$$

When $z = \frac{C_{21} + (1-x)E_{21} - xE_{22} - xI_{23} - I_{21}}{I_{22}}$, make $f(y) = \frac{dy}{dt} = 0$, the tripartite game model with any value of y is in a stable state, and the two strategies of suppliers are game stable strategies.

When $z > \frac{C_{21} + (1-x)E_{21} - xE_{22} - xI_{23} - I_{21}}{I_{22}}$, make $f(y) = \frac{dy}{dt} = 0$, then $y = 0$ and $y = 1$ are stable; under the circumstances, $\left.\frac{df(y)}{dy}\right|_{y=1} < 0, \left.\frac{df(y)}{dy}\right|_{y=0} > 0$, then $y = 1$, is the equilibrium solution, and the suppliers choose the contract compliance strategy as the game stability strategy; on the contrary, $y = 0$ is the equilibrium solution, and the supplier chooses the strategy of not complying with the

contract as the stable strategy. The evolution process of suppliers strategy is shown in Fig. 4.



$$z = \frac{C_{21} + (1-x)E_{21} - xE_{22} - xI_{23} - I_{21}}{I_{22}} \quad z > \frac{C_{21} + (1-x)E_{21} - xE_{22} - xI_{23} - I_{21}}{I_{22}} \quad z < \frac{C_{21} + (1-x)E_{21} - xE_{22} - xI_{23} - I_{21}}{I_{22}}$$

Figure 4 Evolution diagram of suppliers strategy

3)Evolution analysis of grid service providers' strategy. Grid station service providers try their best to ensure that the expected return of community-based online store supply chain revenue is u_{31}, but do not try their best to ensure that the expected return of community-based online store supply chain revenue is u_{32} and the average expected return is u_3, then:

$$\begin{aligned} &u_{31} = I_{31} - C_{31} + x\left(I_{32} - E_{32}\right); \\ &u_{32} = -yE_{31} \end{aligned} \tag{8}$$

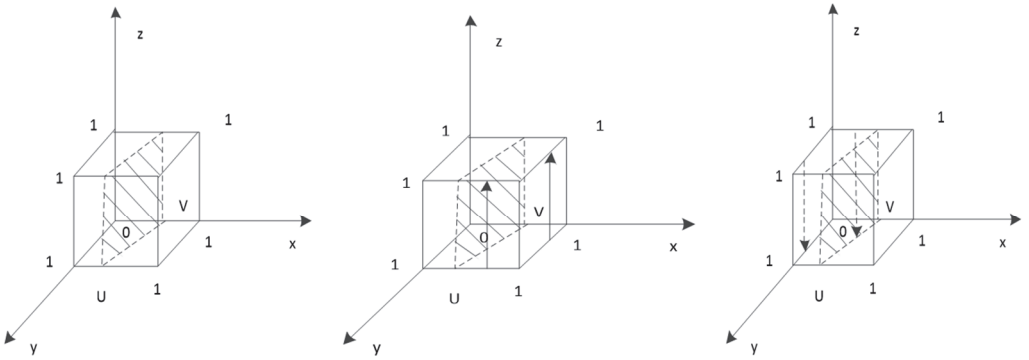
$$\begin{aligned} &u_3 = zu_{31} - (1-z)u_{32} = z\left[\left(I_{31} - C_{31}\right) + X\left(I_{32} - E_{32}\right)\right] + \\ &+(1-z)\left(yE_{31}\right) \end{aligned} \tag{9}$$

The replication dynamic equation of grid station service providers is:

$$\begin{aligned} &f(z) = \frac{\mathrm{d}z}{\mathrm{d}t} = z(1-z)\left(u_{31} - u_{32}\right) = z(1-z) \\ &\left[\left(I_{31} - C_{31}\right) + x\left(I_{32} - E_{32}\right) + yE_{31}\right] \end{aligned} \tag{10}$$

When $x = \frac{C_{31} - I_{31} - yE_{31}}{I_{32} - E_{32}}$, make $f(z) = \frac{\mathrm{d}z}{\mathrm{d}t} = 0$, any value of z is stable, and both strategies of grid station service providers are game stable strategies.

When $x > \frac{C_{31} - I_{31} - yE_{31}}{I_{32} - E_{32}}$, make $f(z) = \frac{\mathrm{d}z}{\mathrm{d}t} = 0$, then $z = 0$ and $z = 1$ are stable. Under the circumstances, $\left.\frac{\mathrm{d}f(z)}{\mathrm{d}z}\right|_{z=1} < 0, \left.\frac{\mathrm{d}f(z)}{\mathrm{d}z}\right|_{z=0} > 0$, then $z = 1$ is the equilibrium solution, grid station service providers choose the best-effort strategy as the game stability strategy, whereas when $z = 0$ is the equilibrium solution, grid station service providers choose the non-best-effort strategy as the game stability strategy. The evolution process of grid service providers strategy is shown in Fig. 5.



$$x = \frac{C_{31} - I_{31} - yE_{31}}{I_{32} - E_{32}} \quad x > \frac{C_{31} - I_{31} - yE_{31}}{I_{32} - E_{32}} \quad x < \frac{C_{31} - I_{31} - yE_{31}}{I_{32} - E_{32}}$$

Figure 5 Evolution diagram of grid station service providers strategy

3 SIMULATION ANALYSIS

Simulation analysis can make the model more intuitive, which can not only verify whether the game model is feasible in practice, but also analyze the appropriate supervision time of community-based online store and the game evolution process of community-based online store under different supervision levels, and can also make up for the deficiency of pure theoretical analysis, making the research more complete and credible. At the same time, by learning from other scholars to apply the evolution of tripartite game to time supervision, it shows that it is appropriate to introduce simulation analysis. By setting appropriate parameters to simulate the dynamic game process and strategy selection of the other two settled enterprises under different supervision conditions of the

community-based online store, this paper puts forward appropriate suggestions for the supply chain supervision time of the community-based online store.

Therefore, mat lab software is used to simulate the supervision time of community-based online store, so as to obtain the influence of the change of supervision delay parameters of community-based online store on the stability strategy of the other two settled enterprises in the evolutionary game process. According to the simulation results, it provides a more scientific and reasonable theoretical basis for community-based online store to effectively supervise grid station service providers and suppliers.

Table 3 Evolutionary stability strategy

	Supervise		Not supervise	
	Observe the agreement	Not observe the agreement	Observe the agreement	Not observe the agreement
Best effort	(1, 1, 1)	(1, 0, 1)	(0, 1, 1)	(0, 0, 1)
Not best effort	(1, 1, 0)	(1, 0, 0)	(0, 1, 0)	(0, 0, 0)

3.1 Assignment of Simulation Parameters

In the following simulation experiments, in order to make the simulation process under different evolutionary stability strategies more ideal, the assignment of parameters is investigated through many experiments, as shown in Tab. 4.

Table 4 Initial parameters setting

Initial parameter	C_{11}	E_{13}	I_{12}	E_{12}	C_{12}	E_{11}	I_{11}
Evaluation	7	10	2	5	1.5	3	2

At the same time, the parameter a is assigned five times to study the influence of the supervision delay degree of community-based online store on the strategic choice of community-based online store and the supervision timing of community-based online store under different strategy combinations of grid service providers and suppliers. The five values are respectively 0.1, 0.3, 0.5, 0.7 and 0.9, and the corresponding degree of supervision delay is very low, low, general, high and very high.

3.2 Strategy Evolution Simulation of Supplier Compliance with Contract

When the suppliers abide by the contract; y=0, at this time, there are six evolutionary stabilization strategies, and the results are shown in Fig. 6 and Fig. 7.

(Remarks: The horizontal axis markings of the Fig. 6 to Fig. 9 both are t, the vertical axis markings of the Fig. 6 to Fig. 9both are *x*. *x* represents the probability of community e-commerce platform supervision, and its scope is (0, 1), so *x* has no unit. *t* represents the supervision time of community e-commerce platform, and the unit is 1.)

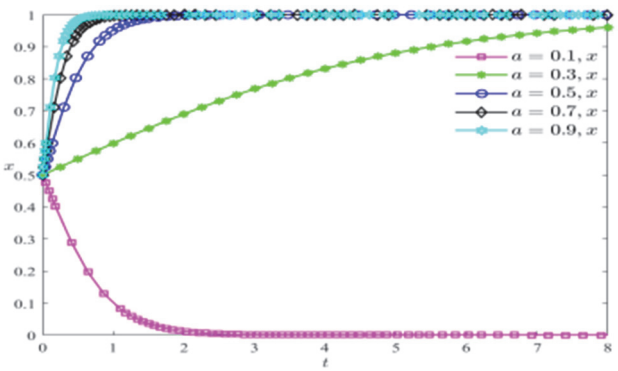


Figure 6 Strategy evolution of Community e-commerce platform

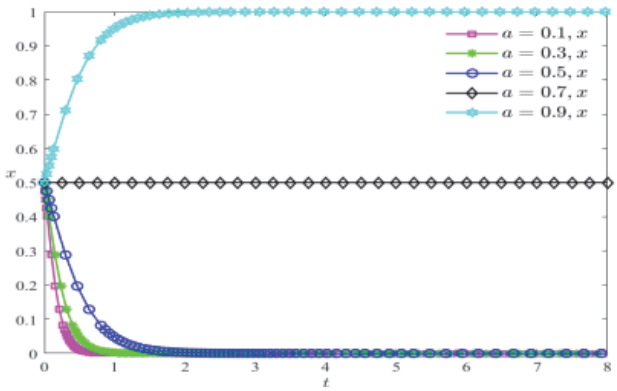


Figure 7 Strategy evolution of community e-commerce platform

When $C_{31} - I_{31} - E_{31} < 0$, $x > \frac{C_{31} - I_{31} - E_{31}}{I_{32} - E_{32}}$ is satisfied, and the grid station service providers choose the best effort, that is, $z = 1$. The simulation diagram is shown in Fig. 6. As shown in the figure, when $a = 0.1$, the degree of supervision delay is low, and the community-based online store tends to choose not to supervise. When suppliers abide by the contract, grid service providers try their best, and the community-based online store is supervised earlier, it will affect the resentment of the enterprises that settled in the community-based online store, which is not conducive to the development of the community-based online store. At the same time, the cost of the community-based online store is greater than the revenue, and if the supervision effect is not good, it will also lead to an increase in cost, thus reducing the revenue of the community-based online store. When $a = 0.3, 0.5, 0.7, 0.9$, the degree of delay gradually increases, and the community-based online store tends to be supervised. When the suppliers abide by the contract, the grid service provider try their best to ensure the revenue of the community-based online store.

When $\frac{C_{31} - I_{31} - E_{31}}{I_{32} - E_{32}} > 1$ and $x < \frac{C_{31} - I_{31} - E_{31}}{I_{32} - E_{32}}$, the grid station service providers choose not to do their best, that is, $z = 0$, and the simulation is shown in Fig. 7. As shown in the figure, when $a = 0.1, 0.3, 0.5$, the community-based online store chooses not to supervise, indicating that when the suppliers abide by the contract and the grid station service providers do not try their best, the community-based online store will be supervised too early, which will make the sales of the community-based online store decline, affecting the revenue of the community-based online store; when $a = 0.7$, the probability of

supervision and non-supervision of community-based online store is 0.5 each; when a = 0.9, the community-based online store chooses supervision, which indicates that even if the grid station service providers will have late delivery, consumers pay more attention to the quality of goods provided by the community-based online store supply chain. As shown in Tab. 5, it is the strategy combination when the suppliers abide by the contract.

Table 5 Suppliers abide by the contract (y = 1)

Number	Prerequisite	Strategy of grid station service providers	Simulation diagram	Assignment of a	Community e-commerce platform strategy	Combination of strategies
1	$C_{31}-I_{31}-E_{31}<0$, $x>\frac{C_{31}-I_{31}-E_{31}}{I_{32}-E_{32}}$	best effort (z = 1)	Fig. 6	a = 0.1	not supervise	(0, 1, 1)
2				a = 0.3, 0.5, 0.7, 0.9	supervise	(1, 1, 1)
3	$\frac{C_{31}-I_{31}-E_{31}}{I_{32}-E_{32}}>1$ $x<\frac{C_{31}-I_{31}-E_{31}}{I_{32}-E_{32}}$	notbest effort (z = 0)	Fig. 7	a = 0.1, 0.3, 0.5	not supervise	(0, 1, 0)
4				a = 0.7	0.5supervise	(1, 1, 0)
5					0.5not supervise	(0, 1, 0)
6				a = 0.9	supervise	(1, 1, 0)

3.3 Simulation of Strategy Evolution when the Suppliers Do not Comply with the Contract

When the suppliers do not abide by the contract; y = 0. At this time, there are three evolutionary stabilization strategies, and the results are shown in Fig. 8 and Fig. 9.

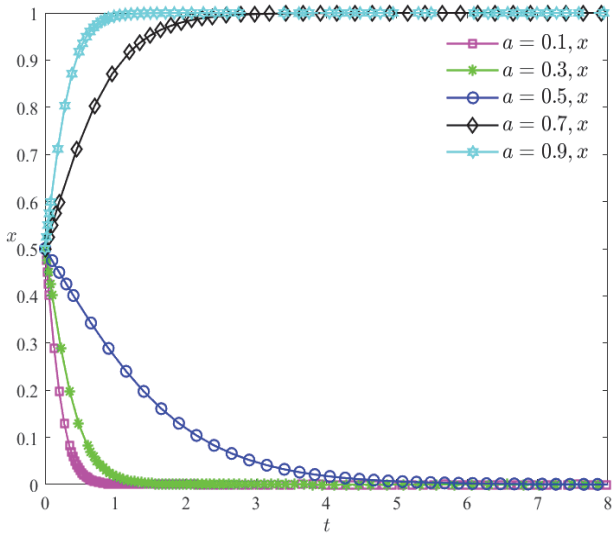


Figure8 Strategy evolution of community e-commerce platform

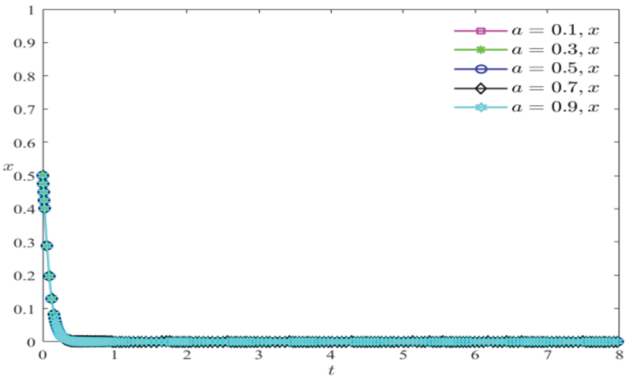


Figure 9 Strategy Evolution of Community E-commerce Platform

When $C_{31}-I_{31}<0$, $x>\frac{C_{31}-I_{31}}{I_{32}-E_{32}}$ is satisfied, and grid station service providers choose the best effort, that is, z = 1, the simulation diagram is shown in Fig. 8. As shown in the figure, when a = 0.1, 0.3, 0.5, the degree of supervision delay is low, and the community-based online store tends to choose not to supervise. When the suppliers do not comply with the contract, the grid service providers try their best, and the community-based online store supervises earlier, it will affect the resentment of the community-based online store entering the enterprise, which is not conducive to the development of the community-based online store. At the same time, it will also make the consumer experience worse. If the supervision effect is not good, it will also lead to an increase in cost. When a = 0.7 and 0.9, the degree of supply chain delay to community-based online store gradually increases, and community-based online store tends to be supervised. When suppliers abide by the contract, grid service providers try their best to ensure the benefits of community-based online store.

When $\frac{C_{31}-I_{31}}{I_{32}-E_{32}}>1$, $x<\frac{C_{31}-I_{31}}{I_{32}-E_{32}}$ is satisfied, and the grid station service providers choose not to do their best, that is z = 0. The simulation diagram is shown in Fig. 9. As shown in the figure, when a = 0.1, 0.3, 0.5, the community-based online store chooses not to supervise, indicating that when the suppliers do not comply with the contract and the grid station service providers try their best, the community-based online store will be supervised too early, which will make the community-based online store Sales declined, affecting the revenue of the community-based online store; when a = 0.7 and 0.9, the community-based online store chooses supervision, which indicates that even if the grid station service providers will have late delivery, consumers pay more attention to the quality of goods provided by the community-based online store supply chain. As shown in Tab. 6, it is the strategy combination when the suppliers abide by the contract. However, in strategy 9 (0, 0, 0), the grid service providers do not do their best, the suppliers do not abide by the contract, and the community-based online store does not supervise, which is not in line with the actual situation.

Table 6 Suppliers do not abide by the contract ($y = 0$)

Number	Prerequisite	Strategy of grid station service providers	Simulation diagram	Assignment of a	Community e-commerce platform strategy	Combination of strategies
7	$C_{31} - I_{31} < 0$, $x > \frac{C_{31} - I_{31}}{I_{32} - E_{32}}$	best effort ($z = 1$)	Fig. 8	$a = 0.1,\ 0.3,\ 0.5$	not supervise	(0, 0, 1)
8				$a = 0.7,\ 0.9$	supervise	(1, 0, 1)
9	$\frac{C_{31} - I_{31}}{I_{32} - E_{32}} > 1$, $x < \frac{C_{31} - I_{31}}{I_{32} - E_{32}}$	notbest effort ($z = 0$)	Fig. 9	$a = 0.1,\ 0.3,\ 0.5,\ 0.7,\ 0.9$	not supervise	(0, 0, 0)

4 CONCLUSIONS AND COUNTER MEASURES

In this paper, the supply chain of community e-commerce platform is selected as the research object, and the evolutionary game theory is introduced to analyze on the basis of existing research. Firstly, the research problem is described, and relevant assumptions are put forward. The assumptions include the three elements of the game and the definition of related concepts. Among them, when setting the main parameters, the introduction of delay parameter *a* indicates the supervision opportunity of community e-commerce platform. Then, based on the dynamic evolution game equation, a tripartite game evolution model of "community e-commerce platform-grid station service provider-supplier" is constructed, and the equilibrium solution is solved to analyze the process and result of tripartite game in the process of supply chain supervision of community e-commerce platform. Then, the MATLAB software is used to simulate the model, and the evolution process and results of each agent's strategy under different delay degrees are studied. The results show that when the delayed supervision parameter *a* of community e-commerce platform increases, community e-commerce platform tends to choose "supervision"; Facing the different strategy combinations of grid station service providers and suppliers, different delays of community e-commerce platforms have different influences on the slope of probability evolution curve of community e-commerce platforms, that is, the regulatory willingness of community e-commerce platforms. Finally, according to the simulation results, some countermeasures and suggestions are put forward for the community e-commerce platform.

The final conclusions are as follows:

(1) The timing of choosing and supervising community-based online store depends not only on the strategic choice of grid service providers and community-based online store in tripartite game. The delay parameter A of community-based online store also has great influence on the supervision timing of community-based online store. Whether and when the community-based online store should be supervised depends on other factors, and other subjects should be integrated to make a choice.

(2) Individual or occasional suppliers do not abide by the treaty and grid station service providers deliver goods overtime for a short time, which will not cause too much impact on consumers' experience, while the cost of supervision is greater than the benefits after supervision, and even cause market chaos after supervision. The resentment of settled enterprises may even withdraw from the supply chain of community-based online store, which will affect the benefits of community-based online store supply chain. At this time, community-based online store can choose not to supervise.

(3) How the community-based online store can quickly and timely discover the default problems of the settled enterprises and improve the supervision efficiency of the community-based online store is also a problem to be solved.

Combined with the actual situation and the analysis of this paper, the following countermeasures are put forward for the supply chain of community-based online store:

(1) Encourage consumers to report. As the main participant in the supply chain revenue of community-based online store, consumers' user experience directly affects the sales volume of products on community-based online store, and consumers should timely feedback the quality of products to community-based online store during the process of purchasing products. Therefore, the community-based online store can timely standardize the settled enterprises. The supervision efficiency of community-based online store can be improved through the participation of consumers.

(2) Formulate the reward and punishment system for the settled enterprises. Establish appropriate incentive mechanism for settled enterprises. For suppliers who abide by the contract and grid station service providers who try their best to ensure the supply chain revenue of community-based online store, increase the proportion of revenue reward, so as to improve the enthusiasm of enterprises. Community-based online store, as an important part of the supply chain of community-based online store, should strengthen its supervision responsibilities. Under certain circumstances, community-based online store can increase the punishment for violations of settled enterprises, and impose strict punishment or blacklist on businesses that do not comply with treaties or do not try their best to ensure the benefits of community-based online store supply chain. Establish appropriate incentive mechanism for settled enterprises. Suppliers who abide by the contract and grid station service providers who try their best to ensure the supply chain revenue of community-based online store should be rewarded accordingly.

(3) Formulating a reasonable supervision system. Community-based online store should set up a special area to supervise the enterprises settled in the community-based online store, so as to improve the efficiency of community-based online store supervision. Add blockchain and other related technologies to the supply chain of community-based online store, and make use of information visibility. Because blockchain technology supports the information visibility of goods in the whole logistics delivery process,

this data is difficult to tamper with in the blockchain database, and can open the freight information of the whole transportation stage to all participants in the supply chain, thus ensuring the safety of goods transportation, and supervising the distribution process of grid station service providers, making the benefits of community-based online store open and transparent.

5 ACKNOWLEDGMENTS

This paper was financially supported by Social and Public Utilities Innovation Project of Hebei Provincial Department of Science and Technology (22375414D) of China which made the present work possible.

6 REFERENCES

[1] Wangxiaoye. (2020). On the legal regulation of "two-choice" behavior of e-commerce platform. *Modern Law Science, 42*(3), 151-165.

[2] Zhang, M, Qiao, H., Wang, X., Ming-zhe, P., Zhi-jun, Y., & Feng-tian, Z. (2015). The third-party regulation on food safety in China: a review. *Journal of Integrative Agriculture*, *14*(11), 2176-2188. https://doi.org/10.1016/S2095-3119(15)61114-5

[3] Wu, B., Cheng, J., & Song, Y. (2020). Evolutionary game analysis of the phenomenon of "killing cooks" in e-commerce platform from the perspective of psychological account. *Operations Research and Management Science, 29*(11), 37-44.

[4] Zhang, S., Fei, W., & Tong, Sh. (2020). Effective governancemechanism of digital economy platform: a case study of cross-border e-commerce platform supervision. *Commercial research*, (4), 49-55.

[5] Wang, L., Wan, J., & Zhang, Y. (2021). Trustworthiness two-way games via margin policy in e-commerce platforms. *Applied Intelligence*, (5), 1-19. https://doi.org/10.1007/s10489-021-02553-6

[6] Salmina, S. V., Khafizova, E. K., & Balabanova, Y. N. (2021). Educational research on solving real tax problems in cross-border e-commerce. *Propósitos y Representaciones*, *9*, 1291-1297. https://doi.org/10.20511/pyr2021.v9nSPE3.1291

[7] Sheng, J., Zhou, W., & Zhu, B.(2019). The coordination of stakeholder interests in environmental regulation: lessons from China's environmental regulation policies from the perspective of the evolutionary game theory. *Journal of Cleaner Production*, *249*, 119385-119410. https://doi.org/10.1016/j.jclepro.2019.119385

[8] Wang, Z., Wang, Q., Chen, B., & Wang, Y. (2019). Evolutionary game analysis on behavioral strategies of multiple stakeholders in e-waste recycling industry. *Resources Conservation And Conservation And Recycling, 155*, 1-9. https://doi.org/10.1016/j.resconrec.2019.104618

[9] Dongping, P., Fei, X., & Guanhui, Y. (2020).Active supervisionstrategies of onlineride-Hailing based on the tripartite evolutionary game model. *IEEE ACCESS*, *8*, 149052-149064. https://doi.org/10.1109/ACCESS.2020.3012584

[10] Bin, W., Jing, C., & Yuqing, Q. (2020). Tripartite evolutionary game analysis for "Deceive acquaintances" behavior of e-commerce platforms in cooperative supervision. *Physica A-statistcal Mechanics and Its Applications*, *550*, 123892-123908. https://doi.org/10.1016/j.physa.2019.123892

[11] Yang, K., Wang, W., & Xiong, W. (2021). Promoting the sustainable development of infrastructure projects through responsible innovation: An evolutionary game analysis. *Utilities Policy*, *70*, 1-11. https://doi.org/10.1016/j.jup.2021.101196

[12] Wang, Y., Wang, D., Shi, X. (2021). Exploring the dilemma of overcapacity governance in China's coal industry: a tripartite evolutionary game model. *Resources Policy*, 71, 1-18. https://doi.org/10.1016/j.resourpol.2021.102000

[13] Xiao, M. (2022). Supervision strategy analysis on price discrimination of e-commerce company in the context of big data based on four-party evolutionary game. *Computational Intelligence and Neuroscience*, 1-25. https://doi.org/10.1155/2022/2900286

Contact information:

Ziyu LIU, Professor
School of Economics and Management,
Hebei University of Science and Technology,
Shijiazhuang, China
E-mail: purpleyuliu@163.com

Lixia ZHAO, Postgraduate
School of Economics and Management,
Hebei University of Science and Technology,
Shijiazhuang, China
E-mail:1540892068@qq.com

Changli WU, Professor
(Corresponding author)
School of Economics and Management,
Hebei University of Science and Technology,
Shijiazhuang, China
E-mail:147893879@qq.com