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Strategy Analysis of Multi-Agent Governance on the E-Commerce Platform

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Abstract: In the post-epidemic era, the e-commerce industry has become an important engine to promote the new round of growth in China's economy. However, the frequent quality problems of products, such as shoddy goods and improper products in the market, not only violate the legitimate rights and interests of consumers and social and public interests, but also seriously restrict the steady and sound development of the e-commerce industry. This paper uses evolutionary game theory to build an evolutionary game model between the government, platform, and merchants, and it analyzes the stable evolution path of the game system and the key factors affecting product quality optimization under the situation of dual strategy set, and then it expands the game side strategy set into a continuous type and compares and explores the regulatory effects and quality output changes under the two situations. Then, it puts forward effective measures to improve the quality of e-commerce products. The findings are as follows: in the case of a binary strategy set, it is difficult for merchants to steadily evolve towards compliance management, while merchants' violation management only has the willingness to improve their efforts when the scale of consumers is small. In the case of continuous policy set, government-enterprise cooperative supervision can realize the compliance operation of merchants, and the effort level and income of merchants are consistent with the optimal value in the case of dual policy set. The results show that the government and e-commerce platforms should adhere to the concept of dynamic regulation and adjust the regulatory strategies according to the different development stages of enterprises so as to not only give merchants sufficient development space, but also to maintain the healthy development environment of the market. At the same time, the government and e-commerce platforms should also avoid the binary choice of supervision or neglect, adopt flexible regulatory strategies, and maintain moderate flexible regulation so as to achieve the development trend of compliance, efforts, and profits of merchants.

Keywords: e-commerce platform; multi-agent governance; evolutionary game; quality output



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1. Introduction

In the post-epidemic era, the economic vitality of the e-commerce industry has been fully released, effectively stimulating the consumption demand of the domestic market and providing strong impetus for the government to promote the resumption of work and production, rural revitalization, and economic growth [1]. According to the 50th Statistical Report on the Development of the Internet in China released by China Internet Network Information Center in August 2022, by June 2022, the online retail sales of physical goods in China reached 5.45 trillion yuan (CNY), accounting for 25.9% of the total retail sales of consumer goods. It will play a positive role in building a bridge between production and consumption, online and offline communication, and in building a new development pattern. With the rapid development of the e-commerce industry, there are frequent disturbances in the market, such as shoddy goods and mismatched goods [2]. According to data released by “Dian-Su-Bao” (315.100EC.CN), a well known Chinese online consumer dispute mediation platform, in the first half of 2022, complaints about commodity quality,

fake promotions, and online counterfeit sales accounted for 15.5% of all online consumer complaints, seriously damaging consumers' legitimate rights and interests and the good momentum of the industry's development. It can be seen that effective supervision of problems, such as the high number of fake and shoddy products and inconsistent online and offline quality in the e-commerce industry, have become key topics to promote the continuous optimization of the quality of e-commerce products and the steady development of the e-commerce industry.

In order to regulate the healthy and orderly development of the e-commerce industry, China officially implemented the E-commerce Law of the People's Republic of China on 1 January 2019. As the first comprehensive law in the field of e-commerce, its provisions clearly stipulate that e-commerce operators should fulfill the obligation to protect the rights and interests of consumers and assume the responsibility for product and service quality and other contents [3]. In the following years, the state and relevant departments of the industry actively explored the formulation of regulatory policies. The State Administration for Market Regulation, the Advertising Association of China, the Cyberspace Administration of China, and other departments have successively issued a number of laws, regulations, rules, and regulations, such as the Guiding Opinions on Strengthening the Supervision of Network Broadcast Marketing Activities, the Measures for the Supervision and Administration of Network Transactions, the Code of Conduct for Network Broadcast Marketing, and the Measures for the Administration of Network Broadcast Marketing (trial). In order to build a perfect regulatory system framework, these measures standardize and promote the healthy and orderly development of the e-commerce industry. After long-term governance practice, the multi-agent governance model has gradually been fully recognized by policy makers.

2. Literature Review

2.1. Multi-Agent Governance and the Role of Participating Agents

2.1.1. The Proposal of Multi-Agent Governance Model

In the era of digital economy, the market environment and business organization structure are undergoing rapid changes, and it is difficult for the government to define and enforce the behavior of market agents by copying the traditional regulatory model to regulate internet platforms. At the same time, traditional policy measures often lack clear applicability and relevance in the process of regulating internet platforms. After continuous exploration and practice, the governance model of joint participation of multiple agents has been widely adopted by academics, and its proposed root is that scholars generally believe that the governance process can be better carried out only if all relevant agents, such as the government, internet platforms, and the public, are introduced into the governance process. Among them, the government is usually the convener and main decision maker of the governance network, while other socially relevant agents are important components, and each participating agent has different knowledge capabilities, rules of participation, and enforcement powers, which may be complementary and intersecting with each other, and these agents together constitute the internet platform multi-agent governance model [4].

The internet platform multi-agent governance model involves multiple participating agents, such as the government, the internet platform, and the public, and clarifying the applicable participation methods of each agent in the governance structure and the interrelationship are the keys to improving the effectiveness of governance [5]. Zajko M (2016) studied the issue of roles and responsibilities of each subject in the governance process [6]; Zajko M [6] studied the issue of roles and responsibilities of each subject in the governance process; Stier S et al. (2018) used a social network analysis method to analyze and discuss the issue of the role of social media and government in online governance [7]. Stier S et al. [7] used a social network analysis method to analyze and discuss the issue of the role of social media and government in online governance. Therefore, who has the legal right to govern and what kind of right they have is the central issue of multi-agent governance.

2.1.2. The Role of Government in the Multi-Agent Governance Model

Along with the continuous updating and development of internet applications and technologies, governments are paying more and more attention to the management of the internet, and while governance emphasizes the importance of multi-agent participation, the importance of government in it has not diminished. In response to the governance of the internet, governments have issued regulatory legal documents, such as the German “Network Enforcement Act” enacted in January 2018, which specifies that internet companies are obliged to remove content that violates the German criminal code within 24 h of receiving the notice; the UK published a white paper on online harm in April 2019 and a government response in December 2020, proposing that illegal and unacceptable content and activity online be addressed by the UK’s independent telecommunications regulator. Since internet platform governance can be seen as a continuation of the exploration of internet governance issues, the government remains the key agent [8,9].

However, the government suffers from insufficient knowledge and technology to monitor the internet platform market in a timely and accurate manner, and its actions are mostly based on complaints, in other words, the government reacts only after a violation has occurred and the process of dealing with it can be cumbersome [10]. Therefore, the government needs to draw on the role of other agents, while the development of network information technology provides the possibility for the participation of relevant agents and the effective synergy of inter-agent relationships. For example, China has entered the third stage of internet governance since 2003, and the management of the internet has changed from pure regulation to governance, with the implementation of governance rules and practices by official and unofficial organizations in concert. Meanwhile, the change in the development of e-government forms over the years is also a typical example of the government’s socialized distribution of public power, from early e-government to t-government to i-government, where the government has continuously reduced its own functions and scale and accelerated the promotion of interconnection and synergy between the government and social organizations and individuals, aiming at a higher degree of inducing other agents to participate in the governance process [11], indicating that governance power can be concentrated or decentralized among agents.

It can be seen that governments have the ability and willingness to guide other agents, such as internet platforms and the public, to participate in the governance process. At the same time, the effectiveness of each agent’s expertise has been demonstrated in the governance practices.

2.1.3. The Role of Internet Platforms in the Multi-Agent Governance Model

There are direct or indirect network effects between trading parties in the internet market, and the important role of internet platforms as intermediaries is to reduce transaction costs between market participants and help overcome problems, such as market failures and barriers to market transactions. Therefore, the emergence of platforms as an organizational form is necessary and inevitable [12]. It can not only provide online product trading venues for both sides of the market, but also play an important role in the code of conduct for market operations and gradually become an important part of the process of participating in the governance of the internet platform by virtue of its advantageous role in technology and information [13].

Although internet platforms do not have traditional employer–employee types of rigid contractual constraints on platform merchants, the economic benefits of platform merchants are directly influenced by internet platforms, which have obvious flexible management constraints on platform merchants by screening and organizing user-produced content and managing interactions between users. For example, internet platforms, such as Amazon, Alibaba, and eBay bring together a huge number of merchants and users and have considerable say in content selection, ranking, and display [14], reflecting the “managerial” role that internet platforms play for merchants and users [15]. At the same time, the European Commission also gradually attaches importance to the central role

of platforms as key “gatekeepers” of the internet, which shows that platforms share the responsibility of governance as a participant of multiparty governance is in line with the market reality and policy requirements.

However, there is also a certain degree of concern in academia about internet platforms assisting government governance. On the one hand, internet platforms have the dual functions of service providers and regulators of platform users, and they may appear to focus too much on their own economic interests and neglect the overall social benefits in the governance process. In other words, as a member of enterprises in the economic market, internet platforms, while providing intermediary services for sellers and consumers, also have fierce competition with other platform operators to grab a larger market share. Internet platforms are both intermediaries of market transactions and participants in market activities, and the interests and responsibilities of the two roles are not always fully aligned [16–18]. Internet platforms may not actively fulfill their governance responsibilities in order to gain their own economic interests.

On the other hand, internet platforms have too much control over platform merchants, and some scholars worry that when internet platforms gain great market position and economic power, they will appear to disobey the overall unified planning of the government, which will damage the governance effect of the multi-agent governance model. For example, some internet platforms may have discriminatory behaviors, and platform merchants can pay a certain fee so as to achieve a prominent display of their content, which can easily breed unfair competitive behaviors in the market and thus undermine the overall healthy development environment of the internet industry [19]. It is worth noting that this phenomenon is prevalent among many types of internet platforms, such as Google, Amazon, eBay and Booking.com [20,21].

It can be seen that the powerful ability displayed by the internet makes the government hope that internet platforms can strengthen the identification and management of platform merchants and users’ behaviors, while internet platforms can achieve the goal of assisting the government to share the responsibility of governance by taking advantage of their own business models and knowledge technologies, but because of the contradiction between maintaining the public interests of society and obtaining private economic benefits, the government needs to actively find ways to effectively motivate internet platforms to play their role.

2.1.4. The Role of the Public in the Multi-Agent Governance Model

Public participation in a broad sense is considered to be the inclusion of the public in regulatory policy, and its participation takes the form of communication and consultation [22], in which the public contributes resources, such as time, expertise, and their own efforts in exchange for influence on governance decisions. Emerging information and communication technologies provide the conditions for public participation in the governance process, and tools such as social networks and new media platforms constitute the key infrastructure for citizen participation in governance [23–25]. At the same time, data disclosure in government departments also provides the possibility for public participation in governance [23], and the public can access various information, documents, and data sets to become participants in governance. The government has guided the public to participate in the governance process in response to the complex challenges of platform governance, and although the governance network is still mainly dominated by the government, the public, as the most numerous and widely sourced component of the multi-agent governance model, has a key role in the effectiveness of governance [24].

In order to maximize the role of the public in the governance process, the government needs to actively guide more public participation, but due to the limitations of the public in terms of time and expertise, the performance of its participation role requires the effective collaboration of other participating agents. Public participation in the governance process can continuously deepen and enrich the relationship network among the participating agents, break through the original hierarchical boundaries between the public and the

government, change the way the government provides social services to the public [25], and change from the role of mere passive consumption of public services to the role of jointly solving social problems [26]. At the same time, public participation has important implications for both government and internet platforms. On the one hand, the public has a supervisory role on the government to examine the government's waste of public resources, and the government can achieve continuous improvement from responding to public issues and needs [27]; on the other hand, users on the internet have changed from passive information receivers to active information producers and consumers, and may prompt internet platforms to carry out the governance of relevant content on them without being restricted by relevant laws.

It can be seen that the public's role affects all agents of the internet platform multi-agent governance, and it plays the most active monitoring role in the governance process. At the same time, the role of the public depends on the joint role with other agents, requiring public policy makers to fully consider the effective synergy of participating agents so as to optimize the effect of the multi-agent governance model.

2.2. Application of Multi-Agent Governance in E-Commerce Platform

The academic circle has also launched a wide discussion on product quality supervision in the e-commerce industry. Some scholars focus on designing efficient industrial supervision mechanism from the perspective of research and carry out applicability innovation on regulatory concepts and models. For example, Song Linlin and Huang Yazhuo [28] explored effective measures for government supervision of the e-commerce industry from four aspects: behavioral subjects, principles to follow, behavioral procedures, and operational techniques. From the perspective of e-commerce ecosystem, Zhou Deliang and Xu Hongling [29] summarized four modes of compulsory regulation, subordinate regulation, parallel regulation, and independent regulation. Wang Xingang and Lin Yin [30] built a governance mechanism of "suppressing evil from good" to provide reference for regulating the disorder of livestreaming cargo. With the continuous enrichment and development of regulatory practices, current scholars are more likely to observe the supervision of e-commerce product quality from the overall and macro level. For example, Zhou Jianping [31], based on the development characteristics of the e-commerce industry, pointed out that a diversified regulatory system of "government supervision, industry self-discipline, social coordination and market participation" should be established. Similarly, Lan Zhiyong and Wu Wei [32] pointed out that e-commerce supervision should break through the subject boundary of government, enterprises, and social organizations and uphold the principle of collaborative supervision, sharing, and co-governance. Mei Ao and Hou Zhishuai [33] proposed that the rights and responsibilities of all parties should be clarified to effectively protect the legitimate rights and interests of consumers by clarifying the relationship between all parties involved in e-commerce activities and could explore the construction path of modernization of governance capacity with the help of emerging information technology. Further, Zhou Shuo [34] pointed out the legal responsibilities and obligations that e-commerce platforms should undertake by analyzing the liability relationship between merchants carrying goods and e-commerce platforms. It can be seen that it has become a consensus among scholars to fully mobilize all social forces to participate in the quality supervision process of e-commerce products and help the government optimize the effect of industry supervision by taking advantage of the dominant role of all parties, in which e-commerce platforms play the most important role.

Since the government-enterprise collaborative regulation model involves multiple subjects, such as the government, platforms, and businesses, how to design reasonable institutional measures to ensure the effective play of regulation has become the focus of scholars' attention. Considering that the behavior selection of various participants can be regarded as a dynamic changing process influenced by multiple factors, current scholars mostly use evolutionary game theory to explore the quality supervision of e-commerce products. Li Jie et al. [35] built an evolutionary game model between merchants and plat-

forms to explore the influence of online word-of-mouth on the regulation of fake goods in e-commerce market. Miao Yungui et al. [36] explored the optimal quality effort level of merchants and the optimal quality of goods by comparing and analyzing the quality game model under the three operation modes of a platform, self-operation, and comprehensive operation. Ma Shuzhong and Fang Chao [37] used the game theory method to build the “shoddy good” game model and discussed the effective measures of e-commerce platform to regulate the honest operation of merchants. Zhang Li et al. [38] introduced consumer complaints into the supervision mechanism of e-commerce platforms based on game theory and explored effective institutional measures to promote the honest operation of merchants. Wang Dezheng and Zheng Kaisi [39] took consumer feedback mechanism as their research background and used evolutionary game theory to study the selection of e-commerce product quality supervision strategies. Zhu Lilong et al. [40] introduced the consumer feedback mechanism, built an evolutionary game model among the government, platform, and consumers, and they analyzed countermeasures and suggestions for improving commodity quality. Li Chunfa et al. [41] used evolutionary game theory to explain the evolution rule of subject behavior strategy under platform regulation and proposed specific strategies and measures to regulate the behaviors of suppliers and merchants. The above literature provides a solid theoretical basis for this paper to analyze the quality supervision of e-commerce products from the perspective of government-enterprise collaboration with evolutionary game theory.

To sum up, the regulatory model coordinated by the government and the platform has been maturely applied in the supervision of the quality of e-commerce products, and scholars mostly adopt the evolutionary game theory to explore the institutional measures to optimize the regulatory effect. However, the deficiencies of current scholars in the research design process are that they only assume the behavior choice of the government and platform as a binary strategy set of supervision or non-supervision and do not fully consider the possible diversified strategy choices of participants in the actual regulatory process, so that it is difficult to deeply describe the regulatory situation of the quality of e-commerce products. They then reduced the effectiveness of the obtained institutional measures to guide the supervision practice. Therefore, based on the regulatory model framework of government–enterprise collaboration, this paper applies evolutionary game theory to analyze the quality regulation of e-commerce products. By expanding the binary strategy set of game players into a continuous type, the paper discusses the stable evolution of the game system under two situations and the key factors affecting the product quality of merchants. The regulation effect and quality output changes under continuous policy set were compared and analyzed, and then corresponding policy suggestions were put forward for reference by government departments.

Different from the existing studies, this paper focuses more on how to design more flexible governance strategies for the government and platform so as to maximize the quality of e-commerce products. At present, most scholars assume that the behavior choice of the government and platform is a binary strategy set of supervision or non-supervision and do not fully consider the possible diversified strategy choices of participants in the actual regulatory process, which makes it difficult to deeply describe the regulatory situation of e-commerce product quality and to thus reduce the effectiveness of the obtained institutional measures in guiding regulatory practice. The innovation and contribution of this paper are mainly reflected in that the government and the platform set the strategy in the governance process in a more flexible and flexible way and changed the original “scattered” strategy selection to “wired” strategy selection, making the governance effect more accurate and effective. Next, the third part of this paper will set parameters and basic assumptions for the construction of the multi-party co-governance game model of e-commerce platform in detail and elaborate the interest function relationship between various subjects. The fourth part will build a game model in the case of dual strategy set to analyze the stable evolution of the governance system and the optimal quality of e-commerce products. The fifth part will build a multi-party co-governance game model in

the case of continuous strategy set, explore the quality changes of e-commerce products after the government and platform adopt more flexible governance strategies, and then propose more effective governance strategies. The sixth part summarizes the results of the model analysis and puts forward the future research direction.

3. Situation Characterization and Model Hypothesis

In the process of e-commerce product quality supervision, the government and the e-commerce platform (hereinafter referred to as the platform) are both the regulators, and the merchants within the platform (hereinafter referred to as the merchants) are the regulated parties. The behavior choices of the three parties influence each other, and together constitute the government-enterprise collaborative game model of e-commerce product quality supervision. Let the government's policy selection set be $S_1 = \{Regulation, Deregulation\}$, the platform's policy selection set be $S_2 = \{Responsible, Irresponsible\}$, and the merchant's policy selection set be $S_3 = \{Compliance, Violation\}$.

Considering that in the actual supervision process of e-commerce product quality, the government has a balance between regulation and development promotion, and the platform has an attribute conflict between maintaining public interests and obtaining private interests, it is difficult for the government and the platform to strictly follow the binary strategy choice of $S_1 = \{Regulation, Deregulation\}$ and $S_2 = \{Responsible, Irresponsible\}$ when taking regulatory measures against merchants, but to adopt more "intermediate" strategies. Therefore, by introducing the degree of government supervision $x(0 \leq x \leq 1)$ and the degree of platform scrutiny $y(0 \leq y \leq 1)$, this paper expands the set of government and platform strategy selection into a continuous type, where $x = 1$ stands for strict regulation, $x = 0$ for deregulation, $y = 1$ for positive review, $y = 0$ for negative review, and the probability density of x and y in the interval $[0,1]$ is $f(x)$ and $f(y)$, respectively. At the same time, suppose that the probability of business compliance is $z(0 \leq z \leq 1)$, then the probability of illegal operation is $1 - z$. Among them, the compliance operation means that the quality of the products sold by the merchants is consistent with the publicity, while the violation operation means that the merchants appear false publicity and shoddy products in the daily sales process. In order to further describe the government-enterprise collaborative supervision situation of e-commerce product quality, this paper continues to introduce parameters, such as platform power space, merchants' effort level, and consumers' willingness to pay into the game model. The logical setting of each parameter into the model and its impact on the revenue of each game party are shown below.

Hypothesis 1 (H1). *The government-enterprise coordinated supervision of the quality of e-commerce products requires the government to empower the platform and guide it to actively participate in the regulatory process. The right space given to the platform by the government is set as $f(0 \leq f \leq 1)$, and $f = 0$ means it is difficult for the platform to play the role of censorship, and $f = 1$ means that the platform can fully play the role of censorship. Then, when the platform review degree is y , the review cost $c_y = by^2/2$ must be paid, where $b(b > 0)$ is the platform review cost coefficient and $m(m > 0)$ is the platform review capability. At the same time, the participation of the platform in the regulatory process can reduce the cost of government regulation. Therefore, when the degree of government regulation is x , it needs to pay the regulatory cost $c_x = (a/2M - fy/M)x^2$, where $a(a > 0)$ is the cost coefficient of government regulation, and $M(M > 0)$ is the ability of government regulation.*

Hypothesis 2 (H2). *Suppose the effort level of the merchant to provide the product is $n(0 \leq n \leq 1)$, then it needs to pay the output cost $c_z = dn^2/2$, where $d(d > 0)$ is the cost coefficient of the merchant's effort. At this point, the product quality provided by the merchant is $q = q_0 + n(q_1 - q_0)(0 < q_0 < q_1)$, where q_1 and q_0 are the upper and lower limits of product quality. It is assumed that consumers in the market have $\varphi(\varphi > 0)$ minimum requirement for product quality, which follows uniform distribution in the interval $[q_0, q_1]$. When $q > \varphi$, consumers will become users of the platform, then the proportion of consumers becoming users of the platform is $Q = (q - q_0)/(q_1 - q_0)$. Assuming that the number of consumers in the market is A continuum with unit e and all of them are unit*

demands, then the scale of platform users is $U = Qe$. The overall output provided by the platform for the society is $W = Qeq$, and the network value benefit obtained by the platform is $V = k(Qe)^2$, where $k(k > 0)$ is the network value coefficient of the platform.

Hypothesis 3 (H3). Assume that the consumer's willingness to pay for the product price in the market is $p(p > 0)$, which is directly related to the product quality provided by the merchant, and its maximum value is the product unit cost $c_z = d/2$ at the merchant's effort level $n = 1$. Meanwhile, in order to make the transaction between the consumer and the merchant, the condition $p > c_z$ must be established. Assume that p follows uniform distribution in the interval $[dn^2/2, d/2]$, and the price payment expectation of the user is $P = d(1 + n^2)/4$. The merchant obtains $R = PU$.

Hypothesis 4 (H4). In order to reflect the phenomenon of shoddy products and non-on-board goods in the e-commerce market, it is assumed that the output effort level $n = 1$ promised by the merchants to the consumers during illegal operation, but the actual effort level is $n(0 \leq n < 1)$ because the quality of the products provided by the merchants fails to meet the minimum requirements of some users, and the platform will suffer a reputation loss $j = (1 - Q)eh$, where $h(h > 0)$ is the reputation loss of the platform. At this point, if the government supervises, the offending merchant will face the government penalty $z = (1 - Q)e\sigma$ and the platform penalty $v = y\lambda$, where $\sigma(\sigma > 0)$ is the fine given by the government to the offending merchant, and $\lambda = (1 - y)z$ is the joint and several punishment of the government to the platform for the violation of the merchant. If the government does not regulate, the government will suffer a reputation loss $i = (1 - Q)el$, where $l(l > 0)$ is the reputation loss of the government.

The above hypothesis extracts and describes the relationship between the government, the platform, and the merchants in the process of e-commerce product quality supervision, defines the key parameters that affect the returns of each game party, and establishes the functional relationship between the parameters, which provides the basis for the construction of the game model of government-enterprise collaborative supervision of e-commerce product quality. The following part of this paper will successively analyze the evolutionary game model of the government and platform strategy selection under the two situations of dual strategy set ($x = 0$, or $x = 1$; $y = 0$ or $y = 1$) ($x = 0, 1$; $y = 0, 1$) and continuous strategy set ($0 < x < 1$; $0 < y < 1$) and discuss the differences and similarities in the evolution path of the game system under the two situations so as to obtain more practical and instructive policy management suggestions.

4. Game Analysis in the Case of Binary Strategy Sets

4.1. Game Model Construction and Solution

According to the parameter assumptions, under the two situations of dual strategy set, the revenue matrix of government, platform, and merchant is shown in Table 1.

Evolutionary game theory assumes that the evolution speed of a game player's strategy is directly proportional to the probability of choosing the strategy and the degree of higher than average return by adopting the strategy [42]. According to the returns of each game party under different strategy combinations in Table 1, the replication dynamic equations of the government, platform, and merchant can be written as follows:

$$E(x) = x(1 - x)[fy/M + el(1 - n)(1 - z) - a/2M] \quad (1)$$

$$E(y) = y(1 - y)[e\sigma x(1 - n)(1 - z) - b/2mf] \quad (2)$$

$$E(z) = z(1 - z)[e\sigma x(1 - n) + de(n^2 + n - 2)/4] \quad (3)$$

The dynamic system analysis of the replication dynamic Equations (1)–(3) shows that there are nine stagnation points in the game system: $(0,0,0)$, $(0,0,1)$, $(0,1,0)$, $(0,1,1)$, $(1,0,0)$, $(1,0,1)$, $(1,1,0)$, $(1,1,1)$, and (x^*, y^*, z^*) , where $x^* = de(2 - n - n^2)/4e\sigma(1 - n)$, $y^* = a/2f - 2Mbl(1 - n)/dmf2(2 - n - n^2)$, $z^* = 1 - 2d/mfde(2 - n - n^2)$.

Table 1. Revenue Matrix for Government, Platform, and merchant.

Government, Platform, Merchant		Compliance	Violation
Regulation	Responsible	$\begin{aligned} & neq - (a - 2f)/2M \\ & k(ne)^2 - b/2mf \\ & dne(1 + n^2)/4 - dn^2/2 \end{aligned}$	$\begin{aligned} & eq - (a - 2f)/2M \\ & ke^2 - b/2mf - (1 - n)eh \\ & d(e - n^2)/2 - (1 - n)e\sigma \end{aligned}$
	Irresponsible	$\begin{aligned} & neq - a/2M \\ & k(ne)^2 \\ & dne(1 + n^2)/4 - dn^2/2 \end{aligned}$	$\begin{aligned} & eq - a/2M \\ & ke^2 - (1 - n)e(h + \sigma) \\ & d(e - n^2)/2 - (1 - n)e\sigma \end{aligned}$
Deregulation	Responsible	$\begin{aligned} & neq \\ & k(ne)^2 - b/2mf \\ & dne(1 + n^2)/4 - dn^2/2 \end{aligned}$	$\begin{aligned} & eq - (1 - n)el \\ & ke^2 - b/2mf - (1 - n)eh \\ & d(e - n^2)/2 \end{aligned}$
	Irresponsible	$\begin{aligned} & neq \\ & k(ne)^2 \\ & dne(1 + n^2)/4 - dn^2/2 \end{aligned}$	$\begin{aligned} & eq - (1 - n)el \\ & ke^2 - (1 - n)eh \\ & d(e - n^2)/2 \end{aligned}$

In order to judge whether the above stagnation points have local asymptotic stability in the game process, the Jacobian matrix judgment is carried out on each stagnation point to verify whether the eigenvalues have negative real parts. The calculation shows that (x^*, y^*, z^*) is the saddle point of the system, and $(0,0,0)$, $(1,0,0)$, and $(1,1,0)$ are the stable evolution points of the system. At the same time, take the government as an example to analyze the parameter conditions that affect the strategy evolution of the game player. When $fy/M + el(1 - n)(1 - z) - a/2M > 0$, $x = 1$ is the stable evolution direction of the government. When $fy/M + el(1 - n)(1 - z) - a/2M < 0$, $x = 0$ is the stable evolution direction of the government. When $fy/M + el(1 - n)(1 - z) - a/2M = 0$, $0 < x < 1$ is stagnation point, and the stable evolution direction of government strategy is greatly influenced by platform and merchant strategy selection. Similarly, the stable evolution of platform and merchant strategy can also be analyzed, which will not be described here. The evolution parameter conditions of the system stability point are shown in Table 2.

Table 2. Stable points and parameter conditions of evolutionary game.

Equilibrium Point		Parameter Conditions		
$(0,0,0)$	$a > 2Mel(1 - n)$	–	–	–
$(1,0,0)$	$a < 2Mel(1 - n)$	$b > 2mfe\sigma(1 - n)$	$d > 4\sigma(1 - n)/(2 - n^3 - n)$	
$(1,1,0)$	$a < 2f + 2Mel(1 - n)$	$b < 2mfe\sigma(1 - n)$	$d > 4\sigma(1 - n)/(2 - n^3 - n)$	

4.2. Product Quality Analysis in Different Stable States

As can be seen from Table 2, merchants' strategy selection will always evolve steadily in the direction of $z = 0$, indicating that in the case of dual strategy set, neither unilateral strict regulation by the government nor coordinated regulation by the government and the platform can effectively regulate merchants' business behaviors, and merchants' strategies will always evolve toward illegal operations. It is worth noting that, although merchants regard illegal operation as their optimal strategy choice, it only means that there is a deviation between the actual effort level $n(0 \leq n < 1)$ of the merchants and the effort level $n(n = 1)$ promised to consumers, and it does not mean that the merchants will absolutely choose a lower effort level.

Therefore, under the premise of known illegal operation of merchants, how to design relevant parameters to guide merchants to maximize their efforts has become a key issue to be explored. Next, three different scenarios in which the system evolves steadily towards $(0,0,0)$, $(1,0,0)$, and $(1,1,0)$ are analyzed in detail.

4.2.1. Product Quality Analysis in (0,0,0) State

When the government regulation cost coefficient $a > 2Me_l(1 - n)$, the stable evolution state of the game system is (0,0,0). At this point, the government will pay a high cost for strict regulation, and deregulation will become the optimal strategy choice for the government. When the government relaxes regulation, the platform will gain more profits from the illegal operation of merchants. Therefore, if the government, as the dominant regulator, chooses to relax regulation, it will send a negative signal to the platform, leading to the platform to choose the strategy of negative review. However, under the circumstances of government deregulation and negative censorship on the platform, merchants naturally regard illegal operation as their optimal strategy choice. Meanwhile, let $M = 2$, $m = 1$, $e = 1$, $l = 0.5$, $n = 0.7$, $f = 0.4$, $\sigma = 1$, and $a = 2$. The simulation image generated by MATLAB is shown in Figure 1.

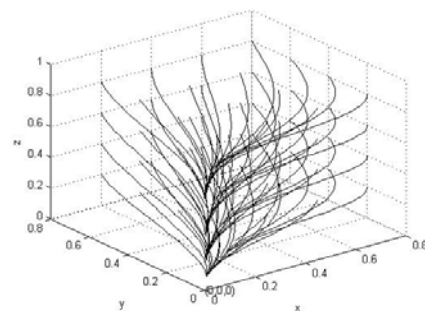


Figure 1. System simulation image in (0,0,0) state.

Figure 1 describes the evolution trajectory of the behavioral strategy selection of the government, platform, and merchants when the cost coefficient of government regulation remains at a high level. It can be seen from Figure 1 that, in this case, no matter what initial state (x,y,z) is in, the system will eventually evolve in the direction of (0,0,0) with the passage of time.

As can be seen from Table 1, when the stable state of the system is (0,0,0), the revenue of merchants is $d(e - n^2)/2$, so that merchants can be guided to consciously improve their effort level to the maximum extent, and the revenue of merchants should be positively correlated with their effort level. If $F(n) = d(e - n^2)/2$ is obtained by the first-order partial derivative of n , $\partial F(n)/\partial n = -dn < 0$ is always constant, indicating that the profit of merchants is always negatively correlated with their effort level. In other words, when the system evolves toward (0,0,0), it is impossible to guide merchants to consciously improve their effort level through parameter configuration, and merchants will minimize their effort level in order to maximize their own profit. It can be seen that under the circumstances of government deregulation, negative-review by platforms and illegal operation by merchants, consumers will only obtain lower-quality products and find it difficult to find solutions.

4.2.2. Product Quality Analysis in (1,0,0) State

When government supervision cost coefficient is $a < 2Me_l(1 - n)$, platform review cost coefficient is $b > 2mf\sigma(1 - n)$, and merchant effort cost coefficient is $d > 4\sigma(1 - n)/(2 - n^3 - n)$, the stable evolution state of the game system is (1,0,0). At this point, the cost of strict supervision is relatively low. In addition, in order to maintain the healthy development of the e-commerce industry and its own reputation, the government will choose strict supervision as its optimal strategy. However, due to the high censorship cost of the platform, it is difficult to guarantee the initiative of the platform to assist the government supervision, and the efforts cost of the merchants is also large, and they have a tendency to choose illegal operation. Therefore, if the government unilaterally chooses strict regulation, it will be difficult to effectively promote platform review and merchant compliance. At the same time, let $M = 2$, $m = 1$, $e = 1$, $l = 0.5$, $n = 0.7$, $f = 0.4$, $\sigma = 1$, $a = 2$,

$b = 2$, and $d = 2$. At this point, the simulation image generated by MATLAB is shown in Figure 2.

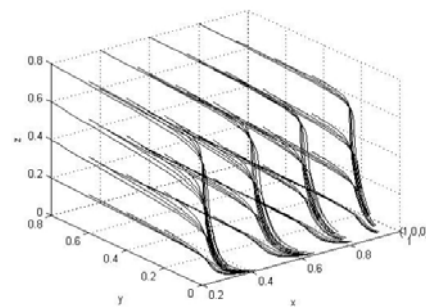


Figure 2. System simulation image in (1,0,0) state.

Figure 2 describes the evolution trajectory of the behavioral strategy choices of the government, platform, and merchants when the cost coefficient of government supervision is kept at a low level and the cost coefficient of platform review and the cost coefficient of merchant effort is kept at a high level. It can be seen from Figure 2 that, in this case, no matter what initial state (x,y,z) is in, the system will eventually evolve in the direction of (1,0,0) over time.

As can be seen from Table 1, when the stable state of the system is (1,0,0), and the profit of the merchant is $d(e - n^2)/2 - (1 - n)e\sigma$. In order to explore how to design relevant parameters to guide the merchant to maximize their efforts, let $H(n) = d(e - n^2)/2 - (1 - n)e\sigma$, and then calculate the first partial derivative of n of the function $H(n)$ to obtain $\partial H(n)/\partial n = -dn + e\sigma$, and then calculate the second partial derivative of n to obtain $\partial^2 H(n)/\partial n^2 = -d < 0$ constant. In order to realize that function $H(n)$ is an increasing function within the interval of $0 \leq n < 1$, the condition $\partial H(n)/\partial n > 0$ must be satisfied, that is, $d < e\sigma$. It indicates that reducing the cost coefficient of efforts of merchants may achieve the result of consciously improving the level of efforts of merchants under the circumstances of strict supervision by the government and negative review by the platform.

In addition, since the cost coefficient of merchant effort at this time needs to meet the condition $4\sigma(1 - n)/(2 - n^3 - n) < d < e\sigma$, let $G(n) = 4\sigma(1 - n)/(2 - n^3 - n)$. Through calculation, it can be seen that function $G(n)$ is negatively correlated on the interval $0 \leq n < 1$ in order to ensure that condition $4\sigma(1 - n)/(2 - n^3 - n) < d < e\sigma$ is established, $n = [(16e - 7e^2)^{1/2} - e]/2e$ or $n = -[(16e - 7e^2)^{1/2} + e]/2e$ (round off) can be obtained by setting $4\sigma(1 - n)/(2 - n^3 - n) = e\sigma$, and $0 \leq n \leq 1$ can be realized within the interval of $1 \leq e \leq 2$. It shows that, although merchants choose illegal operation when the system evolves toward (1,0,0), the government can guide merchants to improve their effort level by reducing their effort cost coefficient. The value range of their effort level is $[(16e - 7e^2)^{1/2} - e]/2e, 1)$, when $1 \leq e \leq 2$. Since the revenue function $H(n)$ of merchants is positively correlated with n , the maximum value of merchants at $n = 1$ is $d(e - 1)/2$, but condition $e = 1$ must be met. It reflects that only when the number of potential consumers in the market is small, measures to improve the effort level of merchants by reducing the effort cost coefficient are meaningful, and the smaller the scale of the merchants' effort level is the largest, and when the number of consumers in the market is $e = 1$, the merchants' effort level $n = 1$ can be achieved, and the maximum profit $d(e - 1)/2$ can be obtained.

The reason is that, when the potential consumer group in the market is small, although a merchant will obtain a higher unit profit by providing low-quality products, due to the small number of consumers, providing low-quality products will lead to the bottom of the number of its users, and the total revenue will not be enough to maintain its own development, and it will face the risk of direct delisting. Therefore, the merchant will consciously improve the level of efforts. However, when there is a large group of potential consumers, due to the influence of demographic dividend, the total income obtained by merchants from providing low-quality products can still realize their own development.

Therefore, merchants will reduce their own efforts. According to the 49th Statistical Report on the Development of Internet in China released by China Internet Network Information Center in February 2022, the number of online shopping users in China has reached 842 million by December 2021. The sheer size and rapid growth of the user base is one reason why businesses don't increase their efforts for fear that their user base will decline. Therefore, in the actual development of our current e-commerce market, it is impossible to ensure the quality of products obtained by consumers through strict supervision by a single government, supplemented by measures to reduce the cost coefficient of merchants' efforts.

4.2.3. Product Quality Analysis in (1,1,0) State

When the cost coefficient of government supervision is $a < 2f + 2Me\sigma(1 - n)$, the cost coefficient of platform review is $b < 2mfe\sigma(1 - n)$, and the cost coefficient of merchant effort is $d > 4\sigma(1 - n)/(2 - n^3 - n)$, and the stable evolution state of the game system is (1,1,0). At this point, the cost required by the platform for active review is relatively low. In order to avoid the possible government punishment during negative review, the platform will choose active review. Due to the assistance of the platform, even if the cost coefficient of government supervision in this situation is somewhat higher, the government will still choose strict supervision in order to achieve the healthy development of the e-commerce industry. However, due to the large cost coefficient of merchants' efforts, they will still choose illegal operation. let $M = 2$, $m = 1$, $e = 1$, $l = 0.5$, $n = 0.7$, $f = 0.4$, $\sigma = 1$, $a = 1$, $b = 0.1$, and $d = 2$. Then, the simulation image generated by MATLAB is shown in Figure 3.

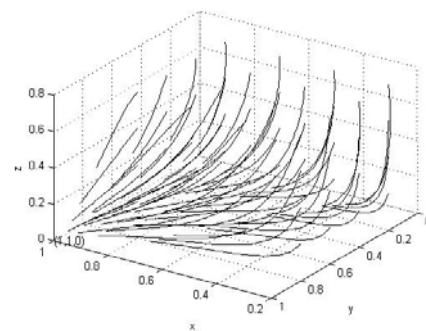


Figure 3. System simulation image in (1,1,0) state.

Figure 3 describes the evolution trajectory of the behavioral strategy selection of the government, platform, and merchants when the cost coefficient of government supervision is relatively low and the cost coefficient of merchants' efforts is maintained at a high level. It can be seen from Figure 3 that, in this case, no matter what initial state (x,y,z) is in, the system will eventually evolve toward (1,1,0) with the passage of time.

Meanwhile, it can be seen from Table 1 that the revenue of merchants in state (1,1,0) is the same as that in state (1,0,0), so the analysis of merchants' effort level in state (1,1,0) can be referred to the analysis results in state (1,0,0), which will not be repeated here. It can be seen that the combination of strict supervision by the government and active review by the platform, supplemented by measures to reduce the cost coefficient of efforts by merchants, cannot guarantee the quality of products obtained by consumers.

Through the above analysis of three different stable evolution states of the game system, it can be seen that: first, even if there are illegal operations of merchants, under the two situations of strict government supervision or coordination between strict government supervision and active review of the platform, merchants can be guided to provide high-quality products by reducing the effort cost coefficient, thus meeting the basic quality requirements of some consumers for products. This also explains why some consumers will not complain even if they encounter the "wrong goods" from the merchants in the market, because the quality of the products provided by the merchants meets the minimum product quality requirements of the users, and considering the complaints channels, costs, and

other factors, consumers choose to passively accept the illegal operation of the merchants. Second, the small scale of consumer groups in the market is a key factor to realize the illegal operation of merchants but still able to take the initiative to improve their efforts. This also explains why the measures to improve the quality of merchant products pointed out in the first point are difficult to take effect effectively in the e-commerce market of our country. At the same time, it also explains the phenomenon of “cutting leeks” in the e-commerce market, that is, in the early stage of business sales, due to the small number of consumers, the quality of business goods is generally high, and so on after the accumulation of a certain number of users, by the temptation of excess profits, the product quality of the business will be difficult to be guaranteed. This conclusion can also be corroborated by the fact that most of the “rollover” behaviors of e-commerce practitioners occur only after they have accumulated some loyal fans.

5. Game Analysis in the Continuous Strategy Set Case

5.1. Model Construction and Stability Strategy Analysis

Based on the model analysis in the above section, it can be seen that, under the condition of dual strategy set, the game system cannot realize the stable evolution of merchants towards compliance operation. However, under the premise of illegal operation of merchants, although parameters can be set to guide them to improve their efforts, the conditions are harsh and difficult to achieve in the reality of Chinese e-commerce market. Therefore, this section expands the strategy selection of the government and the platform into a continuous type and tries to think about the quality supervision of e-commerce products in a more flexible way.

When the government and platform strategy sets are continuous, the probability densities of the degree of government supervision $x(0 \leq x \leq 1)$ and the degree of platform censorship $y(0 \leq y \leq 1)$ in the interval $[0,1]$ are respectively $f(x)$ and $f(y)$, and since the merchant strategy is still a binary strategy set of $S_3 = \{Compliance, Violation\}$, the income of each game party can be obtained by calculating the income of the merchant under the two strategies respectively.

According to the assumptions in Section 2, when merchants operate in compliance, the benefits of the government, the platform, and the merchants are as follows:

$$E_1X(x) = neq - \int \int (a/2M - fy/M)x^2f(x)f(y)dxdy \quad (4)$$

$$E_1Y(y) = k(ne)^2 - \int by^2/2mf(y)dy \quad (5)$$

$$E_1Z = den(1 + n^2)/4 - dn^2/2 \quad (6)$$

When merchants operate violation, the government, the platform and the merchants' earnings are as follows:

$$E_2X(x) = eq - \int \int (a/2M - fy/M)x^2f(x)f(y)dxdy - \int (1-x)(1-n)elf(x)dx \quad (7)$$

$$E_2Y(y) = ke^2 - \int by^2/2mf(y)dy - (1-n)eh - \int \int x(1-x)(1-n)e\sigma f(x)f(y)dxdy \quad (8)$$

$$E_2Z = de/2 - dn^2/2 - \int x(1-n)e\sigma f(x)dx - \int \int xy(1-y)(1-n)e\sigma f(x)f(y)dxdy \quad (9)$$

Since the probability of compliance is z and the probability of illegal operation is $1 - z$, the expected revenue of the government, platform, and merchants is:

$$EX(x) = (1 - z + zn)eq - \int \int (a/2M - fy/M)x^2f(x)f(y)dxdy - el(1 - z)(1 - n) \int (1 - x)f(x)dx \quad (10)$$

$$EY(y) = ke^2(1 - z + zn^2) - \int by^2/2mf(y)dy - e(1 - n)(1 - z)[h + \sigma \int \int x(1 - y)f(x)f(y)dxdy] \quad (11)$$

$$EZ = dez(n^3 + n - 2)/4 - d(e - n^2)/2 - e\sigma(1 - n)(1 - z)[\int xf(x)dx + \int \int xy(1 - y)f(x)f(y)dxdy] \quad (12)$$

In the game process, players will always change their strategies in the direction of improving their own returns, so that the degree of government supervision $x=1$ $x \gg 1$ is promoted and condition $\partial EX(x)/\partial x > 0$ is required to be constant. By solving the first and second partial derivatives of x for Formula (10), we can obtain:

$$\partial EX(x)/\partial x = el(1 - z)(1 - n) - 2x \int (a - 2fy)/2Mf(y)dy \quad (13)$$

$$\partial^2 EX(x)/\partial x^2 = -2 \int (a - 2fy)/2Mf(y)dy \quad (14)$$

According to parameter setting, $\partial^2 EX(x)/\partial x^2 < 0$ is constant, indicating that $\partial EX(x)/\partial x$ is a decreasing function within the range of $0 \leq x \leq 1$, and then the condition of government supervision degree $x \gg 1$ is: $(2f - a)E(y)/M + el(1 - z)(1 - n) > 0$. Similarly, the conditions of platform review degree $y \gg 1$ are as follows: $e\sigma(1 - z)(1 - n) - b/mf > 0$; Since the merchant's strategy selection is still a binary strategy set, the condition for the merchant to evolve towards compliance operation is $E_1Z > E_2Z$, that is, $dez(n^3 + n - 2)/4 + e\sigma(1 - n)E(x)[1 + E(y) - E(y^2)] > 0$.

Therefore, under the continuous interval strategy, the conditions for the game system to evolve towards (1,1,1) are as follows:

$$a < 2fE(y) + Mel(1 - z)(1 - n) \quad (15)$$

$$b < mfe\sigma(1 - n)(1 - z)E(x) \quad (16)$$

$$d < 4\sigma(1 - n)E(x)[1 + E(y) - E(y^2)]/(2 - n^3 - n) \quad (17)$$

According to conditions (15)–(17), under the three conditions of merchants' effort level $n = 1$, merchants' probability of compliance operation is $z = 1$, and the mathematical expectation of strict government supervision is $E(x) = 0$, and the condition for the game system evolving toward (1,1,1) under the continuous interval strategy is not established, indicating that the system cannot be stabilized in the optimal state (*Regulation, Responsible, Compliance*) when merchants make full efforts and operate in compliance or the government relaxes regulation. It reflects the inertia of government and platform participation in regulation and the necessity of strict regulation by the government. At the same time, whether the continuous interval strategy set game system will evolve to point (1,1,1) has nothing to do with the value of $E(y)$, indicating that the behavioral strategy choice of the government and merchants is the key factor affecting the final evolution result of the system.

In addition, it can be seen from condition (15) that the smaller z value is and the larger $E(y)$ value is, the easier it is for the government to evolve towards strict regulation. The reason is that, when the probability of compliance is low, the government will take more initiative to adopt strict regulatory measures in order to maintain a healthy environment for the development of e-commerce. At the same time, the improvement of the positive degree of censorship on the platform will also play a role in assisting the government's supervision, thus increasing the government's willingness to strictly supervise. It can be seen from condition (16) that the smaller z value is and the larger $E(x)$ is, the easier it is for the platform to evolve towards active review. The reason lies in the fact that, when the probability of business compliance is low, the platform will increase its own enthusiasm for examination in order to avoid the risk of reputation loss and large-scale loss of users. At the same time, the improvement of the government's strict supervision will also increase the fine loss of the platform's passive review and thus increase the platform's willingness to actively review. It can be seen from condition (17) that, when $E(x)$ is larger and $E(y)$ is moderate, it is easier for merchants to evolve towards compliance operation. The reason

is that when the government strictly supervises the business, it will face a higher risk of fine, so the probability of compliance will be increased. It is worth noting that when the degree of active review on the platform is in the moderate range, it is more conducive for merchants to adopt compliance management. Compared with the binary strategy set game system, it can be seen that, when the platform only has two strategies of active review and negative review, the punishment effect of the platform on merchants is difficult to achieve. However, when the degree of active review of the platform is in the moderate range, the punishment effect of the platform on merchants will reach the optimal.

In order to explore the influence of key parameters, such as right space given by the government to the platform, group size of consumers in the market, and fine given by the government to the violators on the evolution of the game system towards the optimal state $\{Regulation, Responsible, Compliance\}$, assuming $x = y = z = 0.5$ is constant, conditions (15)–(17) can be simplified as:

$$a < f + Me\sigma(1 - n)/2 \quad (18)$$

$$b < mfe\sigma(1 - n) \quad (19)$$

$$d < 5\sigma(1 - n)/(4 - 2n^3 - 2n) \quad (20)$$

As can be seen from conditions (18)–(20), the above conditions can be more easily satisfied by improving the rights space, government supervision capacity, platform review capacity, consumer group size in the market, and fines imposed by the government on merchants violating the rules, that is, to improve the probability of the game system evolving toward the optimal state ($\{Regulation, Responsible, Compliance\}$).

As for the effort level of merchants, reducing its value can promote the evolution of the government towards strict supervision and the evolution of the platform towards active review. It reflects that only when the merchants do not make efforts, the government and the platform will actively play their own regulatory responsibilities, which confirms the inertia of the government and the platform in the regulatory process. At the same time, lowering the effort level of merchants can help merchants evolve towards compliance operation, which reflects that, only when the merchants do not need to pay too much effort level, they have a higher willingness to comply with the operation. However, even if the merchants comply with the operation, the quality of the products they provide to consumers is low, and it is difficult to achieve the purpose of e-commerce product quality supervision. Therefore, in reality, the government and the platform cannot improve the probability of merchants' compliance operation by reducing the requirements on merchants' effort level, but they should take measures to reduce the cost coefficient of merchants' effort to guide merchants' compliance operation.

5.2. Product Quality Analysis under Continuous Strategy

According to the model analysis results, in the case of continuous strategy set, the game system can evolve toward $\{Regulation, Responsible, Compliance\}$. In order to explore the optimal effort level that merchants will take at this time, it can be known from Formula (6) that the revenue of merchants in compliance operation is $E_1Z = de(1 + n^2)/4 - dn^2/2$. By calculating the first-order, second-order, and third-order partial derivatives with respect to n , $\partial E_1Z/\partial n = de(1 + 3n^2)/4 - dn$, $\partial^2 E_1Z/\partial n^2 = 3de/2 - d$ and $\partial^3 E_1Z/\partial n^3 = 3de/2$ can be obtained, respectively. When $\partial^3 E_1Z/\partial n^3 > 0$ is constant, then $\partial^2 E_1Z/\partial n^2$ is an increasing function in the interval of $0 \leq n \leq 1$. We know that $-d \leq \partial^2 E_1Z/\partial n^2 \leq 3de/2 - d$, and at $n = 2/3e$, there is $\partial^2 E_1Z/\partial n^2 = 0$, and then we can see that $\partial E_1Z/\partial n$ is a decreasing function in the interval of $[-d, 2/3e]$, and it is an increasing function in the interval of $[2/3e, 3de/2 - d]$, and at $n = 2/3e$, $\partial E_1Z/\partial n$ is the smallest $de/4 - d/3e$.

If we set $de/4 - d/3e > 0$, we can obtain $e > 2/3^{1/2}$, and then $\partial E_1Z/\partial n > 0$ is constant, and then E_1Z is an increasing function at $0 \leq n \leq 1$, and its maximum value at $n = 1$ is $d(e - 1)/2$. This indicates that, in this case, the merchant will not only comply with the operation, but also its effort level $n \gg 1$, and obtain the maximum profit $d(e - 1)/2$. When $de/4 - d/3e < 0$, $0 < e < 2/3^{1/2}$ is inconsistent with the market reality, so this case is dropped.

It can be seen that after expanding the strategy set of the government and the platform into A continuous type, the game system may realize a stable evolution toward the state of {*Regulation, Responsible, Compliance*}, and, in the reality that there are a large number of consumers in the current e-commerce market, the government and the platform can guide merchants to improve their efforts by setting relevant parameters to meet conditions (15)–(17). At the effort level $n = 1$, the maximum revenue $d(e - 1)/2$ is obtained, which is equal to the optimal revenue of the merchant in the case of the binary strategy set. However, in the case of binary strategy set, the scale of consumers in the market needs to be small to achieve this purpose, while in the case of continuous strategy set, the scale of consumers in the market needs to be large to achieve this purpose. Therefore, the regulatory strategy under the continuous strategy set is more in line with the market reality and has more advantages.

6. Conclusions and Limitations

The important role of government-enterprise coordinated regulation in maintaining the healthy development of the e-commerce industry has been widely recognized by all walks of life. However, due to the balance between government regulation and the promotion of development, as well as the attribute conflict between the platform in safeguarding public interests and obtaining private interests, the regulatory body in the actual market cannot be a single “tube” or “regardless” of the idea to formulate the corresponding system measures. Based on evolutionary game theory, which has been mature applied in the regulatory issues, this paper establish the regulatory model framework of government–enterprise collaboration. This paper applies evolutionary game theory to analyze the quality regulation of e-commerce products. By expanding the binary strategy set of the game subject into a continuous type, the paper discusses the stable evolution of the game system and the key factors affecting the product quality of merchants under the two situations and compares and analyzes the regulatory effects and quality output changes under the continuous strategy set. Then, the corresponding policy suggestions for the reference of government departments are put forward.

When building the multi-party governance model of e-commerce platforms, this paper focuses more on the governance role of the government, platforms, and the public, but does not deeply consider the role of other social subjects such as the media and third-party industry organizations. In the future, it is necessary to further enrich the degree of fitting between the theoretical model and the real governance environment to improve the effectiveness of governance strategies. At the same time, the collusion strategy between the government and internet platforms, as well as the dual identity conflict between internet platform service providers and market regulators, should also become the focus of future scholars to carry out relevant governance research.

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