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A Game Analysis-Based Behavioral Interaction Framework between Governments and Innovative Enterprises for Intellectual Property Regulation Policies

Qianqian Gu * and Lei Hang

Business School, Shanghai Normal University Tianhua College, Shanghai 201815, China; hanglei@jejunu.ac.kr
* Correspondence: qianqian_0611@163.com

Abstract: Although the Chinese government has issued and revised a series of policies and regulations on intellectual property, infringement still repeatedly occurs. China is in a critical period of economic transformation and upgrading, and the problem of intellectual property infringement is becoming increasingly prominent. Accordingly, in this study, an evolutionary game analysis-based behavioral interaction framework between innovative enterprises and local government regulators, based on evolutionary game theory, was constructed. The strategy choice of both sides of the game and the evolutionary stability of the system were analyzed, and the evolutionary path of each equilibrium point was verified by simulation. The results show that the proposed framework is complex; the dynamic evolutionary system has different evolutionary equilibrium states under different institutional environments. Profit is not the only factor affecting the behavior decision of enterprises; the behavior strategies of governments also have an effect, and the interaction is mutual. Under the government supervision mode, innovative enterprises gradually evolve into the non-infringement strategy under the pressure of external supervision. However, the policy cost of this mode is too high for it to be the optimal solution for regulatory policy. Under the mode of no government supervision, the innovation incentive policy gives enterprises the internal motivation to innovate, results in a relative reduction in the infringement income, and blocks the inducement of infringement. This can effectively control enterprise infringement to realize the sustainable development of enterprises and ultimately achieve the desired objectives of government regulatory policy.

Keywords: regulation policy; intellectual property infringement; evolutionary game theory; evolutionary stable strategy; simulation

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1. Introduction

Creativity, innovation, and intellectual property have become the hallmarks of sustainable development. Intellectual property is an essential indicator for evaluating innovation and research and development (R&D). It is a strategic resource for national economic development and a core element in improving international competitiveness [1]. Moreover, it plays a more critical role in economic development, especially for technological innovation enterprises that rely on patents and other intellectual property rights. It has become a significant participant in social innovation and R&D activities. Intellectual property is a kind of intellectual labor achievement of the creator, and an intangible asset of an enterprise protected by law. Due to the intellectual property infringement characteristics, such as strong concealment, the difficulty of investigation, the challenge of gathering proof when infringement is identified, and the difficulty of determining the loss [2], supervision of intellectual property is complex and the infringement cost is low. Therefore, the proliferation of intellectual property infringement is severe. According to statistics, in 2021, the Intellectual Property Court of the Supreme People's Court of China received 3176 new technical intellectual property cases and concluded 2787 cases. Compared with the same period in 2019, the number of cases received increased by 2390 and the number of cases concluded increased by 2027, and the closing rate increased from 73.7% to 79.8% [3,4]. Figure 1 shows the number of newly added and concluded cases of technological intellectual property infringement in China from 2019 to 2021. Although the court has continuously improved its trial quality and efficiency, it has not effectively restrained the gradual growth in the number of intellectual property infringement cases due to both enterprise factors and the responsibility of local government regulators [5]. After the closing of the Second Session of the 13th National People's Congress in 2019, Premier Li Keqiang said in response to a reporter's question: "We will also strengthen the protection of intellectual property rights, amend the Intellectual Property Law, introduce a punitive compensation mechanism for infringements, deal with them as soon as they are found, and make infringements of intellectual property rights nowhere to escape." This shows the attitude of the Chinese government towards violations and its determination to govern.

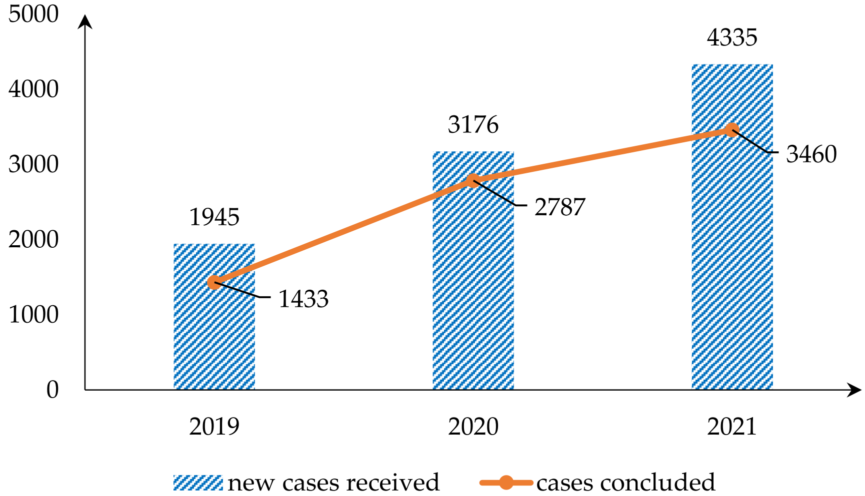

Figure 1. Trend chart of the number of newly added and concluded cases of technological intellectual property infringement in China from 2019 to 2021.

In order to strengthen the management of intellectual property rights, Japan and China promulgated relevant laws and regulations on intellectual property information disclosure in 2014 and 2018, respectively, to regulate the disclosure of intellectual property information [6]. In order to curb the occurrence of patent infringement [7], the United States and China successively introduced punitive damages into their patent laws. Furthermore, various countries formulated a series of intellectual property protection systems and built a relatively sound system [8]. However, due to the paucity of financial resources and human capital, the protection of intellectual property rights in developing countries is relatively weaker than that in developed countries [9]. Grossman et al. [10] also found that differences in market size and capacity for research and development can also lead to differences in patent policies among countries.

A series of intellectual property policies and regulations have not effectively curbed the occurrence of infringement. Therefore, scholars have studied the issue of intellectual property infringement from different perspectives. Du et al. [11] proposed that the lack of public awareness of intellectual property system norms is the internal cause of infringement. Cui [12] believed that the lack of some intellectual property legal systems and the weak intensity of infringement punishment led to infringement. Regarding the issue of intellectual property infringement, enterprises are the main object of behavior guidance and governance, and their behavioral strategies are not only affected by the legal system, but also by the behavioral strategies of local government regulators. Therefore, some scholars have explored the means to effectively govern intellectual property infringement based on the interactive relationship between enterprises and local government regulators. Zhang et al. [13] explored the impact of government regulatory attitude on infringement by analyzing the game relationship among original manufacturers, infringing manufacturers, local government regulators, and users in the software market. Banerjee et al. [14] studied the impact of government law enforcement on the intellectual property behavior of enterprises by analyzing a two-stage dynamic game model between the government and infringing enterprises. Yi [15] explored a new way to use digital technology to strengthen the prevention of intellectual property infringement and government supervision.

Many scholars have successfully applied evolutionary game theory to the study of various practical problems in social life [16–20]. The game relationship between the government and enterprises is a long-term and repeated process, under the influence of information asymmetry and other external conditions, which will gradually reach a certain dynamic equilibrium in the process of the continuous game. However, the complexity of the economic environment and the game problem itself leads to bounded rationality on both sides. Thus, the game relationship between the government and enterprises as applied to intellectual property issues has two characteristics: first, repeated learning and continuous strategy adjustment; second, bounded rationality. Evolutionary game theory involves the study of the dynamic evolutionary process of a group changing over time, and the factors affecting its change from the perspective of bounded rationality [21]. The authors of [22] used evolutionary game theory to analyze the behavior choice of different enterprise subjects under the influence of carbon tax, and the authors of [23] used this theory to analyze the behavioral interaction mechanism among governments, port enterprises, and transportation enterprises under environmental regulation. Based on the environmental regulation policy, Gu et al. [24] explored the pollution control strategies of governments and enterprises under the influence of third-party supervision with the help of this theory. These studies used evolutionary game tools to explore the game relationship between game players under a specific policy system. Therefore, using evolutionary game theory to explore the behavioral interaction mechanism between innovative enterprises and local government regulators in intellectual property issues closely resembles the actual situation.

From the existing quantitative research on intellectual property infringement, scholars have deepened their research methods on the game relationship between participants, as mainly reflected in the transition from a static game to a dynamic game. However, few studies exist on the game relationship between the government and enterprises using the evolutionary game method. Therefore, in this study, based on the evolutionary game theory, a game model between innovative enterprises and local government regulators was constructed in the context of intellectual property infringement. The evolutionary law and equilibrium state of the two under different policy environments were explored in a switching model of dynamic replicator policies. The main contributions of this paper are as follows:

1. By addressing the limitation of the perfect rationality of the game players, this paper explores the behavior of evolutionary law between the government and enterprises from the perspective of bounded rationality. Moreover, at the same time, it also expands the application field of evolutionary game theory.
2. This paper uses numerical simulation to verify the evolutionary path and equilibrium results of government–enterprise strategies under different institutional conditions.

The remainder of this paper is structured as follows. Section 2 introduces the related work on intellectual property infringement. Section 3 constructs the evolutionary game model between local governments and innovative enterprises in the context of the problem of intellectual property, and solves the model's dynamic equations. Section 4 analyzes the evolutionary stability of government–enterprise strategies under different policy environments. Section 5 performs numerical simulation to verify the analysis and conducts sensitivity analysis on key variables. Section 6 summarizes the main conclusions and findings, the limitations of the paper, and future work.

2. Related Work

In light of the research theme, the related literature was reviewed and analyzed. Scholars have mainly carried out research in terms of two aspects: improving and evaluating related policies and regulations, and analyzing participants' behavior and influence factors in infringement.

2.1. Research on Policies and Regulations

The laws and systems related to intellectual property protection are essential for combating infringement. Many scholars proposed effective ways to protect intellectual property, such as continuously strengthening theoretical research, improving and perfecting intellectual property laws and regulations [25–27], and promoting the construction of the administrative law enforcement system [28,29]. Marlyna et al. [30] evaluated and analyzed Indonesia's trademark theory and trademark law. This research reported that most studies used utilitarianism and economic theories to demonstrate the role of trademark protection regulation in protecting consumers; however, it provided minimal protection, having only legal and philosophical arguments, and was limited to simply safeguarding consumers from being misled or deceived by stipulation. Thus, they concluded that protecting customers was not the Indonesian trademark law's primary objective.

From the perspective of qualitative research and case analysis, the authors of [31] carried out research on the specific problems of more scientifically and reasonably determining the amount of tort compensation to provide theoretical support for the judicial practice. Based on the relevant theories of the academic and judicial judgments, the authors of [32] constructed a model of the impact indicators for calculating the trademark infringement legal compensation amount. Through the analysis of the practical judgment cases of the Beijing Intellectual Property Court in 2018, the authors explored the impact indicators of legal compensation for trademark infringement to optimize the trademark infringement compensation system in China. The author of [33] discussed the construction of an intellectual property infringement compensation system from the macro perspective and found that intellectual property holders can strive for more interests. The infringement would be more rigorously deterred by continuously optimizing the intellectual property infringement compensation system and properly introducing an infringement punitive compensation system.

From the perspective of quantitative analysis, the authors of [34] used a war of attrition game theory model to explain different intellectual property rights in piracy and protection situations. They concluded that the establishment of free intellectual property zones can effectively solve the problem of intellectual property infringement. Therefore, Manuel et al. proposed the idea of establishing free intellectual property zones, which represent a sui generis intellectual property regime.

2.2. Research on Behavioral Analysis of Participants and Influence Factors in Infringement

Regarding the infringement of enterprises, the author of [15] explored a new way to strengthen the prevention and supervision of intellectual property infringement using digital technology. In [35,36], the authors believed computer technology may be used to detect suspected intellectual property infringement, effectively prevent and find infringement activities, and protect intellectual property. Aiming to realize the intelligent software supervision of broadcasting infringement in Indonesia, Endah et al. [37] designed an integrated system to detect broadcast infringement, which contained two main stages: Indonesian-language speech recognition and detection of infringements of the broadcast program. Hung et al. [38] proposed a trademark infringement recognition assistance system based on human visual Gestalt psychology and trademark design, which can provide visually compelling quantitative data and effectively prevent competitors' trademark counterfeiting through psychology.

In terms of government regulation, some studies showed that effective regulation can govern the intellectual property infringement of enterprises. Zhang et al. [13] concluded that the government's policy attitude towards piracy was the main factor affecting the behavior of enterprises, by building a two-stage game model between original manufacturers, infringing manufacturers, local government regulators, and software users. The study suggested the government should achieve a balance between the efficiency of policies and the cost of implementing policies when formulating anti-piracy policies. Banerjee et al. [14] constructed a game mechanism between the government and enterprises with the help of the Stackelberg model to explore their behavior strategies and game relationship, and believed that relying solely on government supervision and punishment may not curb the occurrence of infringement. However, under the legal protection of the law enforcement policy, enterprises can effectively prevent infringement activities when adopting an anti-duplication investment strategy. Based on the theory of social co-governance, Li et al. [39] used evolutionary game theory to explore the intellectual property protection mechanism of e-commerce under government supervision.

In addition to the government, the monitoring subject of intellectual property infringement also includes intellectual property holders. In order to explore the interaction between the holders and the infringers, Takeyama [40] studied their behavior strategies from the perspective of user benefits under the network effect, and concluded that software companies should use price means rather than monitoring methods to curb the occurrence of infringement. Subsequently, Chen et al. [41] found that high prices were the leading cause of software infringement incidents. Crampes et al. [42] established a static and dynamic game model between the patent infringers and the holders, analyzed their strategy choices and influencing factors under these two modes, and found the regulatory cost was the critical factor affecting the holders' behavior strategies. Phelps [43] suggested patent holders should identify critical features from a product and patent perspective as early as possible, keeping the lines of communication open about product changes, to effectively avoid the infringement.

From the related research results of intellectual property infringement, most studies focused mainly on the qualitative analysis of laws and policies, and the creation and optimization of infringement detection technology. Although many scholars focused on infringement supervision, there are relatively few studies on the interaction mechanism between related participants and the internal causes of infringement. In terms of quantitative research, game theory is a good tool, and was investigated in [13,14,34,39,42]. Although these studies are an essential reference for our work, they have some limitations. Therefore, this study attempted to carry out the research from the perspective of the evolutionary game. The main contributions of our work are compared with the related research on game theory in Table 1.

Table 1. Comparison between our study and related studies based on game theory.

Article	Assumption	Research Perspective	Method	Validation Analysis
[13]	Not involved	Governments, intellectual property holders, infringers, and users	Dynamic game	No
[14]	Not involved	Governments, infringing enterprises	Dynamic game	No
[34]	Not involved	Intellectual property holders and infringers	Dynamic game	No
[39]	Bounded rationality	Governments, e-commerce platforms, and intellectual property holders	Evolutionary game	Yes
[42]	Perfect rationality	Intellectual property holders and infringers	Static game and dynamic game	No
Proposed Study	Bounded rationality	Governments and infringing enterprises	Evolutionary game	Yes

3. Basic Assumptions and Game Model

Based on the characteristics of the evolutionary game, it is assumed that both sides of the game carry out long-term dynamic evolutionary activities based on the following assumptions. Combined with the intellectual property policy system and the needs of model construction, the variables discussed below were set in this study. Due to the differences in society, economy, politics, and culture, the regulatory policies of different economies will be different. In order to improve the universality of the model, these factors are included in the model:

Game players: The players are innovative enterprises and local government regulators, and both operate under bounded rationality.

Behavior strategy: Innovative enterprises undertake non-infringement and infringement strategies, and local governments undertake supervision and non-supervision strategies.

The probability of behavior strategy: In the initial stage, the probability of choosing non-infringement behavior in the group of innovative enterprises is x, and the proportion of choosing infringement behavior is $1 - x$. The probability of choosing supervision strategy in the group of local government regulators is y, and the proportion of choosing a non-supervision strategy is $1 - y$, where $x, y \in [0, 1]$, all of which are functions of time t.

Parameters of enterprises: Innovative enterprises need to invest in basic expenses C_1 in carrying out legitimate business activities, and obtain operating income R_1, but they may infringe others' intellectual property rights because of huge profits. The cost of infringement is set as C_2. If government departments supervise the infringement behavior of enterprises, the punishment for infringement will be P_1, and if it is not supervised, the behavior will result in additional income R_2. In order to encourage enterprises to innovate, the government evaluates enterprises according to the evaluation index of innovation quality and implements incentives, such as tax reduction policies and subsidies, or rewards for innovative enterprises, which are recorded as R. Correspondingly, as R increases, R_2 decreases relatively, so the functional relationship between the two can be simplified to a relationship in which they are reciprocal to each other. In order to simplify the calculation, government incentives are not included in the revenue of enterprises.

Parameters of local government regulators: Local government regulators invest in costs C_3 to supervise the innovative enterprises under the law and, at the same time, they will gain reputation, social affirmation, praise, and awards from superior government regulators and other benefits, which can be recorded as R_3. Moreover, primarily when R_3 is used to express social affirmation, it changes with the changes in social, political, and cultural factors α; thus, R_3 is a function of the variable α, denoted by $R_3(\alpha)$. Therefore, different economies can use this variable to express the regulatory revenue of actors. If local government regulators investigate and punish infringing enterprises, the regulators will also receive a reward from their superior regulators. When the regulators choose the non-supervision strategy, the cost input is zero. However, when a third party discloses the infringement behavior of innovative enterprises, the regulators will be blamed by society and punished by their superior regulators for dereliction of duty, which is recorded as P_2.

The definitions of all parameters involved in the basic assumptions are summarized in Table 2.

Table 2. The definitions of parameters in the assumptions.

Parameter	Definition
x	The probability of innovative enterprises choosing a non-infringement strategy
y	The probability of local governments choosing a supervision strategy
C_1	The cost of innovative enterprises required for normal production activities
R_1	The income of innovative enterprises from normal production activities
P_1	Infringement punishment suffered by innovative enterprises from local governments
C_2	The cost of implementing infringement activities by innovative enterprises
R_2	Additional benefits obtained by innovative enterprises from infringement
R	The reward for innovative enterprises innovation from local governments
C_3	The supervision cost of local governments
R_3	The supervision benefits local governments
α	Social, political, cultural, and other factors affecting the supervision benefits of local governments
R_4	External rewards obtained by local governments from the superior governments
P_2	Punishment suffered by local governments for dereliction of duty

Based on these assumptions (the above parameters are more significant than zero), the game rules between innovative enterprises and local government regulators can be used to intuitively display the game tree shown in Figure 2. The evolutionary game's payment matrix is expressed in Table 3.

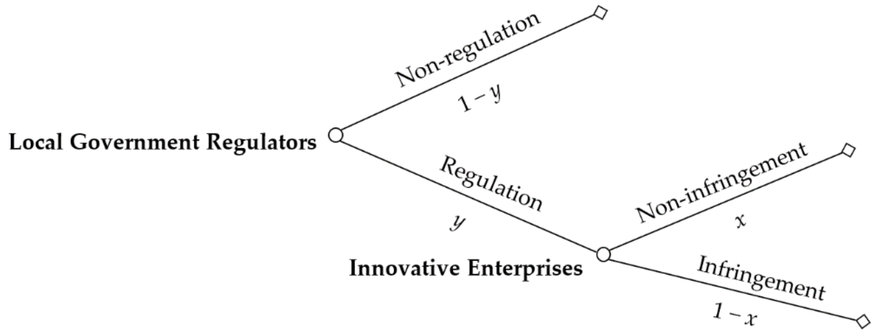

Figure 2. Game tree of evolutionary game model between governments and enterprises.

Table 3. The payment matrix of the evolutionary game model.

		Local Government Regulators	
		Supervision y	**Non-Supervision** $1-y$
Innovative Enterprises	Non-infringement x	$(R_1 - C_1\,,\ R_3(\alpha) - C_3)$	$(R_1 - C_1\,, 0)$
	Infringement $1-x$	$(R_1 - C_1 + R_2 - C_2 - P_1\,,\ R_3(\alpha) - C_3 + R_4)$	$(R_1 - C_1 + R_2 - C_2\,, -P_2)$

First, in light of the game model, the expected revenue of innovative enterprises under different strategy choices can be obtained.

The expected revenue of enterprises choosing a non-infringement strategy is as follows:

$$E_{e0} = y(R_1 - C_1) + (1-y)(R_1 - C_1) \tag{1}$$

The expected revenue of enterprises choosing an infringement strategy is as follows:

$$E_{e1} = \mathrm{y}(R_1 - C_1 + R_2 - C_2 - P_1) + (1-y)(R_1 - C_1 + R_2 - C_2) \tag{2}$$

The average expected revenue of a firm can be expressed as:

$$\overline{E}_E = xE_{E0} + (1-x)E_{e1} \tag{3}$$

Second, the replicated dynamic analysis of the evolutionary game is applied to innovative enterprises, and then its replicated dynamic equation can be constructed:

$$F(x) = \frac{dx}{dt} = x(E_{e0} - \overline{E}_e) = x(1-x)(C_2 - R_2 + P_1 y) \tag{4}$$

In the same way, the replicated dynamic equation of local government regulators can be obtained, as shown in Equation (5):

$$H(y) = y(1-y)[R_3(\alpha) - C_3 + R_4 + P_2 - (R_4 + P_2)x] \tag{5}$$

4. Stability Analysis of Evolutionary Strategies

In light of the stability theorem of differential equations and the properties of evolutionary stable strategies, to ensure a strategy is in a stable state, the probability y of choosing the strategy must satisfy Formula (6):

$$F(x^*) = 0, \quad F'(x^*) < 0 \text{ or } H(y^*) = 0, \quad H'(y^*) < 0 \tag{6}$$

x^* or y^* is now an evolutionarily stable strategy [44].

4.1. Evolutionary Stability Analysis of Innovative Enterprises Strategies

We can derive the replicated dynamic equation of innovative enterprise strategy to obtain:

$$F'(x) = (1 - 2x)(C_2 - R_2 + P_1 y). \tag{7}$$

Let:

$$y_0 = \frac{R_2 - C_2}{P_1}, \tag{8}$$

We can then analyze the evolutionary stability of the parameters in different initial states.

When $y = y_0$, $F(x) = 0$ can be obtained, and x is stable at any level within the value range $[0, 1]$. When $y \neq y_0$, let $F(x) = 0$; both $x^* = 0$ and $x^* = 1$ are stable states. In light of Formula (6), if x^* satisfies $F'(x^*) < 0$, then x^* is an evolutionary stable strategy. (1) When $y < y_0$, $F'(x)|_{x=0} < 0$, so $x^* = 0$ is an evolutionary stable strategy; that is, when the supervision strength of the government group is too small or even abandoned, the innovative enterprises' group will choose the intellectual property infringement strategy. (2) When $y > y_0$, $F'(x)|_{x=1} < 0$, so $x^* = 1$ is an evolutionary stable strategy; that is, when the supervision strength of the government group is strong enough, the innovative enterprises' group will choose the non-infringement strategy. The replicated dynamic phase diagram of innovative enterprises' strategies is shown in Figure 3.

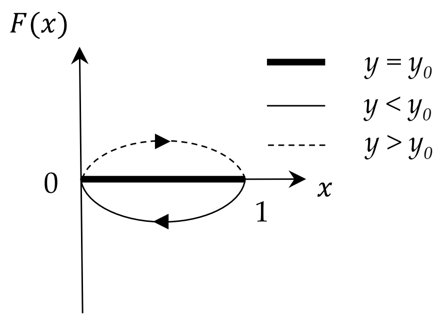

Figure 3. Replicated dynamic phase diagram of enterprises' strategies.

4.2. Evolutionary Stability Analysis of Local Government Regulator's Strategies

Similarly, by deriving the replicated dynamics equation of local government regulator's strategy, we can obtain:

$$H\prime(y) = (1 - 2y)[R_3(\alpha) - C_3 + R_4 + P_2 - (R_4 + P_2)x], \tag{9}$$

and let:

$$x_0 = \frac{R_3(\alpha) - C_3 + R_4 + P_2}{R_4 + P_2}, \tag{10}$$

We can then analyze the evolutionary stability of the parameters in different initial states.

When $x = x_0$, $H(y) = 0$ can be obtained; then, y is stable at any level within the value range $[0, 1]$. When $x \neq x_0$, let $H(y) = 0$, and both $y^* = 0$ and $y^* = 1$ are stable states. In light of Formula (6), if y^* satisfies $H'(y^*) < 0$, then y^* is an evolutionary stable strategy. (1) When $x < x_0$, $H'(y)\big|_{y=1} < 0$, and $y^* = 1$ is an evolutionary stable strategy; that is, when the proportion of individuals who choose the non-infringement strategy in the innovative enterprises' group is very small or even zero, the government group will choose the supervision strategy. (2) When $x > x_0$, $H'(y)\big|_{y=0} < 0$, so $y^* = 0$ is an evolutionary stable strategy; that is, when the proportion of individuals who choose the non-infringement strategy in the innovative enterprises' group is large enough, the government group will choose a non-supervision strategy. The replicated dynamic phase diagram of local government regulators is shown in Figure 4.

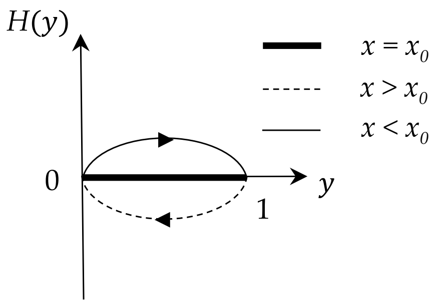

Figure 4. Replicated dynamic phase diagram of local government regulator's strategies.

4.3. Stability Analysis of the Dynamic Evolutionary System

The replicated dynamic system is composed of $F(x)$, and $H(y)$ describes the group dynamics of evolutionary strategies between government and innovative enterprises. Let $F(x) = 0$ and $H(y) = 0$; then, the equations can be obtained as follows:

$$\begin{cases} x(1-x)(C_2 - R_2 + P_1 y) = 0 \\ y(1-y)[R_3(\alpha) - C_3 + R_4 + P_2 - (R_4 + P_2)x] = 0 \end{cases} \tag{11}$$

By solving the equations, five equilibrium cases of the dynamic evolutionary system can be obtained, which are $(0,0)$,$(0,1)$,$(1,0)$,$(1,1)$, and (x_0, y_0), if and only if $0 < x_0, y_0 < 1$. The local stability of the five equilibrium points can be determined by the sign of the determinant *Det*(*J*) and the trace *Tr*(*J*) of the Jacobian matrix *J* of the system.

$$J = \begin{bmatrix} (1-2x)(C_2 - R_2 + P_1 y) & x(1-x)P_1 \\ y(y-1)(R_4 + P_2) & (1-2y)[R_3(\alpha) - C_3 + R_4 + P_2 - (R_4 + P_2)x] \end{bmatrix} \tag{12}$$

According to the Jacobian matrix's local stability analysis method [45], when $Det(J) > 0$ and $Tr(J) < 0$, the equilibrium point has local stability, and the corresponding strategy is the evolutionary stable strategy (ESS). Substituting the five equilibrium points into the Jacobian matrix *J*, separately, the corresponding expressions of *Det*(*J*) and *Tr*(*J*) can be obtained, as shown in Table 4.

Table 4. Expressions of Jacobian determinants and traces of each equilibrium point.

Equilibrium Point	*Det(J)*	*Tr(J)*
(0, 0)	$(C_2 - R_2)(R_3(\alpha) - C_3 + R_4 + P_2)$	$(C_2 - R_2) + (R_3(\alpha) - C_3 + R_4 + P_2)$
(0, 1)	$-(C_2 - R_2 + P_1)(R_3(\alpha) - C_3 + R_4 + P_2)$	$(C_2 - R_2 + P_1) - (R_3(\alpha) - C_3 + R_4 + P_2)$
(1, 0)	$-(C_2 - R_2)(R_3(\alpha) - C_3)$	$-(C_2 - R_2) + (R_3(\alpha) - C_3)$
(1, 1)	$(C_2 - R_2 + P_1)(R_3(\alpha) - C_3)$	$-(C_2 - R_2 + P_1) - (R_3(\alpha) - C_3)$
(x_0, y_0)	$\frac{(R_3(\alpha) - C_3 + R_4 + P_2)(C_3 - R_3(\alpha))(R_2 - C_2)(P_1 - R_2 + C_2)}{(R_4 + P_2)P_1}$	0

After solving, when the equilibrium point is (x_0, y_0), $Tr(J) = 0$; thus, $Tr(J) < 0$ is not satisfied, so this point is certainly not the evolutionary stable state of the system. Therefore, the evolutionary stability of the other four equilibrium points is analyzed below.

Conclusion 1. *When $R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$ are met, the evolutionary stable state of the system is equilibrium point (1, 1), namely, (non-infringement, supervision).*

Proof of Conclusion 1. When $0 < R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$, or $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 > 0$, are met, the local stability analysis results of each equilibrium point of the evolutionary game system are shown in Table 5. According to the results, the system meets $Det(J) > 0$ and $Tr(J) < 0$ at the equilibrium point (1, 1), so the evolutionary stable state of both sides of the game is the equilibrium point (1, 1). By summarizing the above two conditions, $R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$ can be obtained; thus, Conclusion 1 can be obtained. □

Table 5. Stability analysis under conditions $R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$.

Conditions	Equilibrium Point	*Det(J)*	*Tr(J)*	Stability
$0 < R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$	(0, 0)	−	Uncertain	Saddle point
	(0, 1)	−	Uncertain	Saddle point
	(1, 0)	+	+	Unstable
	(1, 1)	+	−	ESS
$R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 > 0$	(0, 0)	+	+	Unstable
	(0, 1)	−	Uncertain	Saddle point
	(1, 0)	−	Uncertain	Saddle point
	(1, 1)	+	−	ESS

"-" indicates that the value of this item is less than zero; "+" indicates that the value of this item is greater than zero. In Tables 6–9, "−" and "+" also have the same explanation.

Conclusion 1 shows that the final state of the system evolution is that innovative enterprises tend to choose legal production. The government tends to choose a supervision strategy when the punishment suffered by enterprises who are found to infringe is more significant than the benefits resulting from the act. The benefits of the government are more significant than the cost input. The rigorous investigation and punishment of infringement, by the government, enables enterprises to see the determination of the government to crack down on illegal acts. Thus, enterprises consciously abide by the law and business ethics. Moreover, it can be seen that the punishment mechanism of infringement can deter enterprises from infringement and effectively curb their infringement behavior.

Conclusion 2. *When $R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > -R_4 - P_2$ are met, the evolutionary stable state of the system is equilibrium point (0, 1), namely, (infringement, non-supervision).*

Proof of Conclusion 2. When $R_2 - C_2 > P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$, or $R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > 0$, are met, the local stability analysis results of each equilibrium point of the evolutionary game system are shown in Table 6. According to the results, the system meets $Det(J) > 0$ and $Tr(J) < 0$ at the equilibrium point (0, 1), so the evolutionary stable state of both sides of the game is the equilibrium point (0, 1). By summarizing the above two conditions, conditions $R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > -R_4 - P_2$ can be obtained; thus, Conclusion 2 can be obtained. □

Table 6. Stability analysis under conditions $R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > -R_4 - P_2$.

Conditions	Equilibrium Point	*Det(J)*	*Tr(J)*	Stability
$R_2 - C_2 > P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$	(0, 0)	−	Uncertain	Saddle point
	(0, 1)	+	−	ESS
	(1, 0)	−	Uncertain	Saddle point
	(1, 1)	+	+	Unstable
$R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > 0$	(0, 0)	−	Uncertain	Saddle point
	(0, 1)	+	−	ESS
	(1, 0)	+	+	Unstable
	(1, 1)	−	Uncertain	Saddle point

Conclusion 2 shows that when the enterprises' income created by the infringement behavior is very high, and higher than the punishment of enterprises for their infringement behaviors, the enterprises will take risks in pursuit of huge profits and choose to infringe regardless of legal constraints. When the higher regulators establish a reward and punishment system for local government regulators, regardless of whether the supervision cost is greater than the supervision income, local government regulators will perform their duties and responsibilities because of the supervision and assessment of the higher regulators. At this time, the system will evolve to the state where the enterprises choose the infringement strategy and local government regulators choose the supervision strategy. Therefore, establishing a reward and punishment system for local government regulators can significantly improve their regulatory efficiency.

Conclusion 3. *When $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < 0$ are met, the evolutionary stable state of the system is equilibrium point (1, 0), namely, (non-infringement, non-supervision).*

Proof of Conclusion 3. When $R_2 - C_2 < 0$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$, or $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$, are met, the local stability analysis results of each equilibrium point of the evolutionary game system are shown in Table 7. According to the results, the system meets $Det(J) > 0$ and $Tr(J) < 0$ at the equilibrium point (1, 0), so the evolutionary stable state of both sides of the game is the equilibrium point (1, 0). By summarizing the above two conditions, conditions $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < 0$ can be obtained; thus, Conclusion 3 can be obtained. □

Table 7. Stability analysis under conditions $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < 0$.

Conditions	Equilibrium Point	*Det(J)*	*Tr(J)*	Stability
$R_2 - C_2 < 0$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$	(0, 0)	+	+	Unstable
	(0, 1)	−	Uncertain	Saddle point
	(1, 0)	+	−	ESS
	(1, 1)	−	Uncertain	Saddle point
$R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > 0$	(0, 0)	−	Uncertain	Saddle point
	(0, 1)	+	+	Unstable
	(1, 0)	+	−	ESS
	(1, 1)	−	Uncertain	Saddle point

Conclusion 3 shows that when the cost of infringement is higher than the benefit of infringement, enterprises will tend not to choose infringement behavior. When the regulatory cost of local government regulators is higher than the benefit, the too-high cost results in a low return. Thus, regulators feel their work has no value, restricting the full effect of regulatory efficiency. As a result, local government regulators will gradually tend to choose a non-supervision strategy.

Conclusion 4. *When $R_2 - C_2 > 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$ are met, the evolutionary stable state of the system is equilibrium point (0, 0), namely, (infringement, non-supervision).*

Proof of Conclusion 4. When $R_3(\alpha) - C_3 < -R_4 - P_2$ and $R_2 - C_2 > P_1$, or $R_3(\alpha) - C_3 < -R_4 - P_2$ and $0 < R_2 - C_2 < P_1$, are met, the local stability analysis results of each equilibrium point of the evolutionary game system are shown in Table 8. According to the results, the system meets $Det(J) > 0$ and $Tr(J) < 0$ at the equilibrium point (0, 0), so the evolutionary stable state of both sides of the game is the equilibrium point (0, 0). By summarizing the above two conditions, conditions $R_2 - C_2 > 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$ can be obtained; thus, Conclusion 4 can be obtained. □

Table 8. Stability analysis conditions $R_2 - C_2 > 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$.

Conditions	Equilibrium Point	*Det(J)*	*Tr(J)*	Stability
$R_3(\alpha) - C_3 < -R_4 - P_2$ and $R_2 - C_2 > P_1$	(0, 0)	+	−	ESS
	(0, 1)	−	Uncertain	Saddle point
	(1, 0)	−	Uncertain	Saddle point
	(1, 1)	+	+	Unstable
$R_3(\alpha) - C_3 < -R_4 - P_2$ and $0 < R_2 - C_2 < P_1$	(0, 0)	+	−	ESS
	(0, 1)	+	+	Unstable
	(1, 0)	−	Uncertain	Saddle point
	(1, 1)	−	Uncertain	Saddle point

Conclusion 4 shows that when the infringement cost is low, the infringement strategy can result in additional benefits to the enterprises. Although there is a risk of being discovered, the enterprises will tend to choose infringement behavior in pursuit of high profits. When the regulatory cost of local government regulators is sufficiently high that the regulatory behavior has no return, or even a negative return, the regulators will gradually tend to choose a non-supervision strategy, which is the worst stable state in the evolutionary process.

Conclusion 5. *When* $0 < R_2 - C_2 < P_1$ *and* $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$ *are met, there is no evolutionary steady state for the dynamic evolutionary system.*

Proof of Conclusion 5. When $0 < R_2 - C_2 < P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$ are met, the local stability analysis results of each equilibrium point of the evolutionary game system are shown in Table 9. According to the results, at this time, none of the four equilibrium points can satisfy $Det(J) > 0$ $Tr(J) < 0$, so there is no evolutionary stable strategy for the system; thus, Conclusion 5 can be obtained. □

Table 9. Stability analysis under conditions $0 < R_2 - C_2 < P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$.

Equilibrium Point	*Det(J)*	*Tr(J)*	Stability
(0, 0)	−	Uncertain	Saddle point
(0, 1)	−	Uncertain	Saddle point
(1, 0)	−	Uncertain	Saddle point
(1, 1)	−	Uncertain	Saddle point

Conclusion 5 shows that when the profit of infringement is less than the punishment of enterprises for their infringement behaviors, the regulatory cost of government regulators is too high, so the profit is negative. Both parties will tend to choose the discouraged behavior (infringement or non-supervision); however, they may also choose the encouraged behavior (non-infringement or supervision) because of excessive punishment loss. The behavior choices between the government and innovative enterprises follow each other and cannot tend to a stable strategy combination. The evolutionary system is in a state of dynamic change.

The above five conclusions' equilibrium conditions and points are summarized as five cases, as shown in Table 10.

Table 10. Evolutionary stable strategies of the dynamic system under different conditions.

Case No.	Conditions	ESS
1	$R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$	(1, 1)
2	$R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > -R_4 - P_2$	(0, 1)
3	$R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < 0$	(1, 0)
4	$R_2 - C_2 > 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$	(0, 0)
5	$0 < R_2 - C_2 < P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$	Non-existent

In cases 1~4 of Table 10, the evolutionary system converges to a pure strategic ESS point. From the pure strategy evolutionary equilibrium results, in the two states of point (0, 1) and point (0, 0), regardless of whether the government implements supervision, enterprises will eventually converge to the infringement strategy; in particular, the strategy combination (infringement, supervision) corresponding to point (0, 1) is the worst evolutionary equilibrium state of non-cooperation between governments and enterprises. Point (1, 1) indicates that innovative enterprises carry out legal production under the supervision of the government. Compared with cases 2 and 4, although the evolutionary results are improved, it is not a sustainable solution to curb enterprise infringement under the strict supervision of the government [46]. The system state in which enterprises consciously carry out legal production activities without government supervision, corresponding to point (0, 1), is the optimal evolutionary equilibrium state of government–enterprise cooperation, and is also the best path with the lowest total cost of the regulation target expected by the government regulation policy.

In case 5 of Table 10, the strategies of government enterprises cannot tend to a stable point, and there is no evolutionary stable state of the dynamic system.

5. Simulation Experiments

5.1. Numerical Simulation Experiments of the Game System in Different Cases

In order to verify the above conclusions and more intuitively present the evolutionary paths of the system under different conditions in the dynamic evolutionary system, MATLAB was used to carry out simulation experiments. In order to show the evolutionary results of government–enterprise strategies under different initial states of the system, the initial values of variables x and y were set as follows: starting from $x = 0$ or $y = 0$, all strategy combinations in the interval [0, 1] were numerically simulated according to the step size of 0.1. Regarding the relevant contents of existing research [47], and in combination with the actual implementation of China's intellectual property policy, the parameter values under the five institutional environments in Table 10 were set. The given values were normalized based on the actual values to simplify the calculation.

According to the conclusions of the above evolutionary stability analysis, five simulation experiments were carried out in the same simulation environment, and are presented in this section. The equipment is LAPTOP-SVI96S0P, and its model is XiaoXinAir-14IIL 2020 (Lenovo, Beijing, China). The computer operating system was Windows 10 10.0.19043 (Microsoft Ltd., Redmond, Washington, DC, USA) with an Intel Core i5-1035G1 CPU @ 1.00 GHz 1.19 GHz processor (Intel, Santa Clara, CA, USA) and 16G memory. The software was MATLAB version 7.0.0.19920 (R14), developed by MathWorks. The simulation experiment environment is shown in Table 11.

Table 11. Simulation environment for evolutionary government–enterprise strategies.

Component	Description
Equipment	Lenovo LAPTOP-SVI96S0P, XiaoXinAir-14IIL 2020
Operating system	Microsoft Windows 10 10.0.19043
CPU	Intel Core i5-1035G1 CPU @ 1.00 GHz 1.19 GHz
Memory	16.0 GB
MATLAB	Version 7.0.0.19920 (R14)

Setting $R_2 = 0.4$, $C_2 = 0.3$, $P_1 = 0.5$, $R_3(\alpha) = 0.4$, $C_3 = 0.3$, $R_4 = 0.3$, and $P_2 = 0.5$, Figure 5 describes innovative enterprises' evolutionary paths and the government results under conditions $R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$ in Conclusion 1. The simulation results show that, regardless of the initial state of the two, the ESS of the dynamic system is (non-infringement, supervision), which is consistent with the research results in Conclusion 1.

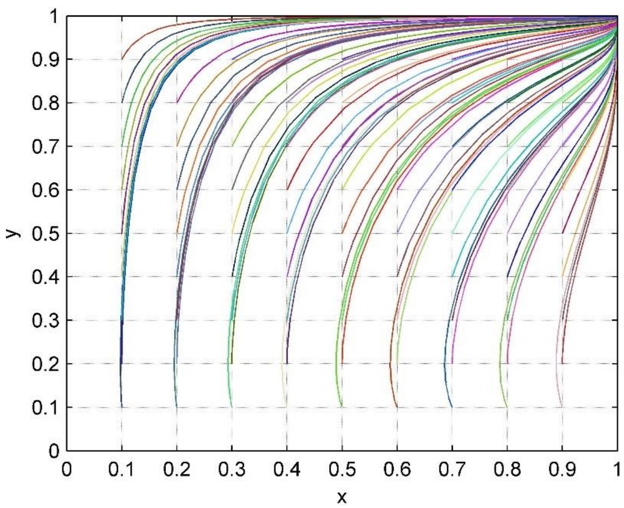

Figure 5. Simulation results of the dynamic system under conditions $R_2 - C_2 < P_1$ and $R_3(\alpha) - C_3 > 0$ covering all strategy combinations of initial states in the interval [0, 1] with the step size of 0.1. Different color lines show the evolutionary paths of different initial states of the system.

Setting R_2 = 0.4, C_2 = 0.1, P_1 = 0.2, $R_3(\alpha)$ = 0.4, C_3 = 0.3, R_4 = 0.3, and P_2 = 0.5, Figure 6 describes innovative enterprises' evolutionary paths and results of the government under conditions $R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > -R_4 - P_2$ in Conclusion 2. The simulation results show that, regardless of the initial state of the two, when enterprises can obtain huge profits by infringing, the ESS of the dynamic system is (infringement, supervision), which is consistent with the research results in Conclusion 2.

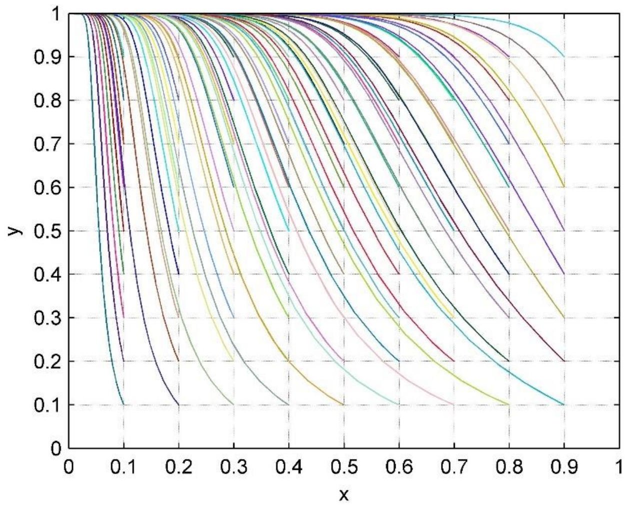

Figure 6. Simulation results of the dynamic system under conditions $R_2 - C_2 > P_1$ and $R_3(\alpha) - C_3 > -R_4 - P_2$ covering all strategy combinations of initial states in the interval [0, 1] with the step size of 0.1. Different color lines show the evolutionary paths of different initial states of the system.

Setting R_2 = 0.3, C_2 = 0.4, P_1 = 0.5, $R_3(\alpha)$ = 0.2, C_3 = 0.4, R_4 = 0.3, and P_2 = 0.5, Figure 7 describes innovative enterprises' evolutionary paths and results of the government under conditions $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < 0$ in Conclusion 3. The simulation results show that, regardless of the initial state of the two, when the infringement cost of enterprises and the supervision cost of local government regulators are too high, the ESS of the dynamic system is (non-infringement, non-supervision), which is consistent with the research results in Conclusion 3.

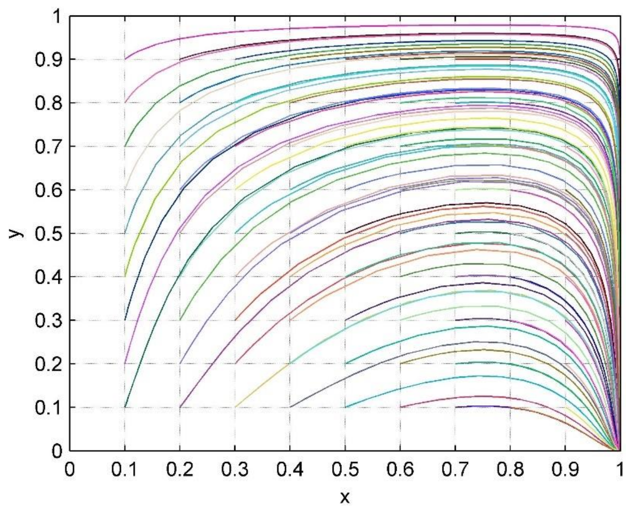

Figure 7. Simulation results of the dynamic system under conditions $R_2 - C_2 < 0$ and $R_3(\alpha) - C_3 < 0$ covering all strategy combinations of initial states in the interval [0, 1] with the step size of 0.1. Different color lines show the evolutionary paths of different initial states of the system.

Setting R_2 = 0.5, C_2 = 0.3, P_1 = 0.5, $R_3(\alpha)$ = 0.1, C_3 = 0.5, R_4 = 0.2, and P_2 = 0.1, Figure 8 describes innovative enterprises' evolutionary paths and results of the government under conditions $R_2 - C_2 > 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$ in Conclusion 4. The simulation results show that, regardless of the initial state of the two, when enterprises can obtain huge profits from infringement and the cost of the government is too high, the ESS of the dynamic system is (infringement, non-supervision), which is consistent with the research results in Conclusion 4.

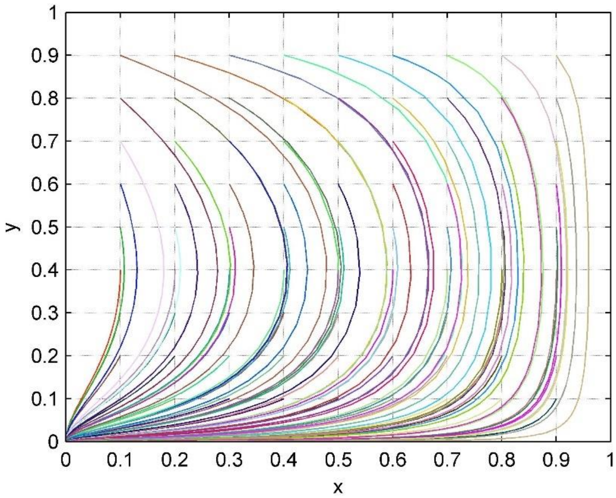

Figure 8. Simulation results of the dynamic system under conditions $R_2 - C_2 > 0$ and $R_3(\alpha) - C_3 < -R_4 - P_2$ covering all strategy combinations of initial states in the interval [0, 1] with the step size of 0.1. Different color lines show the evolutionary paths of different initial states of the system.

Setting R_2 = 0.5, C_2 = 0.3, P_1 = 0.5, $R_3(\alpha)$ = 0.1, C_3 = 0.3, R_4 = 0.2 and P_2 = 0.1, Figure 9 describes the evolutionary paths of the dynamic system under conditions $0 < R_2 - C_2 < P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$ in Conclusion 5. The simulation results show that, regardless of the initial state of the government and innovative enterprises, the strategy selection of the two game groups changes periodically and cannot always tend to a stable state. In addition, the system is in a periodic oscillation state; that is, there is no evolutionary stable state, which is also consistent with the research results in Conclusion 5.

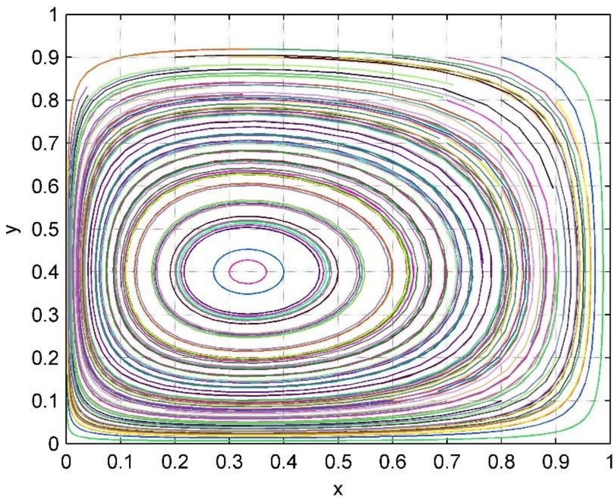

Figure 9. Simulation results of the dynamic system under conditions $0 < R_2 - C_2 < P_1$ and $-R_4 - P_2 < R_3(\alpha) - C_3 < 0$ covering all strategy combinations of initial states in the interval [0, 1] with the step size of 0.1. Different color lines show the evolutionary paths of different initial states of the system.

In summary, regardless of the initial state of innovative enterprises and local government regulators, the evolutionary game system will tend to the corresponding evolutionary stable state if certain conditions are met. This conclusion can provide a reference for system design.

5.2. Sensitivity Analysis

By studying the interaction framework between the government supervision mode and enterprises' behavior under intellectual property regulation, this paper aimed to explore the policy path to effectively curb the occurrence of infringement, encourage enterprises to carry out innovative production, and realize sustainable development of technology and the economy. Therefore, it is necessary to focus on the impact of different policy environments on the strategic evolution of both sides of the game under the two equilibrium states of point (1, 1) and point (1, 0). The research process is as follows: Taking ESS (1, 1) and ESS (1, 0) as the benchmark, respectively, the sensitivity analysis of critical variables is carried out using the control variable method, and the evolutionary path diagrams are drawn to simulate the evolutionary process of the system under different values, which are set according to the regulation policy.

5.2.1. The Simulation of External Reward Policy for Governments under the Mode of Government Supervision

The external reward policy mainly affects the strategy choices of the governments by rewarding their regulatory behavior. The effect of the policy is affected by the reward strength of the superior governments. Improving the external reward can encourage the governments to choose more regulatory strategies, thus improving the probability of infringement being detected and restricting the infringement. In order to simulate the effect of this policy, we keep the values of the other parameters in the benchmark case ESS of (1, 1) unchanged, and set two control groups for the benchmark variables $R_3(\alpha) = 0.4$ and $R_4 = 0.3$, which are $R_3(\alpha) = 0.7$, $R_4 = 0.6$, and $R_3(\alpha) = 1.0$, $R_4 = 0.9$, to simulate the evolutionary paths of both sides of the game. It is observed from the simulation results in Figure 5 that the initial state of the system does not affect the evolutionary trend of either side of the game under the same institutional environment. Therefore, the initial state of the system is randomly set as $x = 0.2$ and $y = 0.3$. The evolutionary paths of the system are shown in Figure 10.

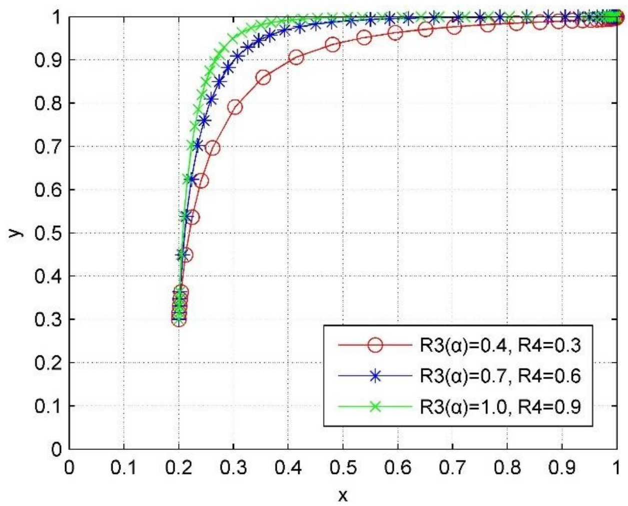

Figure 10. Evolutionary path diagram of the system under different external incentives for governments.

The simulation results in Figure 10 show that when the external reward for government regulatory behavior is increased, the regulatory enthusiasm of governments can be improved, and the rate of evolution of enterprises to a non-infringement strategy can also be accelerated. Under the pressure of external supervision, innovative enterprises tend to choose a non-infringement strategy; however, this is not the spontaneous behavior of enterprises. Once the governments relax supervision, enterprises will implement timely infringement to make huge profits. Furthermore, the policy cost is too high, which means it is not the optimal solution for regulation policy.

5.2.2. The Simulation of Innovation Reward Policy for Enterprises under the Mode of No Government Supervision

A reward or subsidy policy can promote enterprises' innovation [48,49]. The policy effect is affected by the strength of government incentives. Technological innovation can improve the development quality of enterprises and reduce the occurrence of infringement at the core. In order to simulate the effect of this policy, we keep the values of other parameters in the benchmark case ESS of (1, 0) unchanged and set two control values 0.52 and 0.78, for the benchmark variable $R = 0.33$, to simulate the evolutionary paths of both sides of the game (the benchmark value of R can be obtained according to the corresponding relationship between the two). It is observed from the simulation results in Figure 7 that the initial state of the system does not affect the evolutionary trend of both sides of the game under the same institutional environment. Therefore, the initial state of the system is randomly set as $x = 0.1$ and $y = 0.2$. The evolutionary paths of the system are shown in Figure 11.

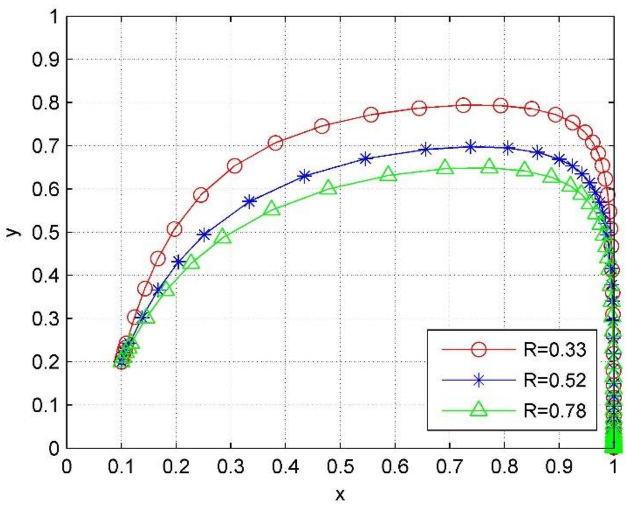

Figure 11. Evolutionary path diagram of the system under different innovation incentives for enterprises.

The simulation results in Figure 11 show that the innovation reward to enterprises directly impacts their behavior—the greater the reward, the faster the evolution of enterprises to a non-infringement strategy. Under government rewards and subsidies, enterprises can consciously carry out legal production without government supervision. In order to improve their competitive market advantage, enterprises will carry out innovative R&D activities to achieve sustainable development. This regulation policy can effectively govern infringement, endow enterprises with the internal motive force of innovation, and realize the "double dividend" of the governments and enterprises.

6. Conclusions

6.1. Research Findings and Suggestions

Based on evolutionary game theory, in this paper, the evolutionary stability of the strategies of the groups of local government regulators and innovative enterprises are analyzed, the dynamic system's evolutionary law and equilibrium state under different institutional conditions are explored, and simulation experiments with computer software are carried out to verify the theoretical analysis. The dynamic system's stability analysis and simulation results show that the behavioral interaction mechanism between local government regulators and innovative enterprises is complex. The system's equilibrium state will change with the dynamic changes in the system and the external environment. The equilibrium state of a single group is not only affected by its strategies, but is also related to the strategies of other groups. The research conclusions and targeted suggestions can be summarized as follows.

First, the cost of infringement and the punishment of local government for infringement are the main factors affecting the intellectual property behavior of innovative enterprises. When the infringement cost is low, the infringement results in high profits for innovative enterprises, which may be much higher than the profits of the regular operation. Enterprises will take risks and infringe others' intellectual property rights. However, with the increase in punishment from local governments for infringing enterprises, the profit space of enterprises gradually shrinks. When the infringement punishment is greater than the infringement benefits, enterprises will cease infringing and choose to operate legally. Therefore, local government regulators need to strengthen the awareness of intellectual property protection of innovative enterprises, and guide them to do an excellent job in property registration application and technical confidentiality, to increase the infringement cost of illegal enterprises. In addition, government regulators need to appropriately improve the punishment for enterprise infringement and accelerate the establishment of a punitive damages system for infringement.

Second, external rewards and reputation income are important factors affecting the behavior choice of local governments. These are also sensitive factors. Positive rewards result in great work value to governments and effectively stimulate their work enthusiasm. In addition, the punishment for dereliction of duty also directly affects the behavior strategy of the government regulators. Therefore, in the process of policy implementation in real society, the superior governments should establish an effective reward and punishment system for local governments to improve the enthusiasm of local government regulators. Furthermore, local governments should regularly carry out public opinion surveys in the process of policy implementation and pay attention to public evaluation.

Third, the innovation reward policy for enterprises can effectively stimulate their innovation motivation and reduce the occurrence of infringement. The government should gradually improve the intellectual property system, incorporate the innovation reward and subsidy policies into the institutional framework, and guide enterprises to spontaneously choose independent innovation behavior. In this way, innovation and creativity can realize a safer and more sustainable future through intellectual property and enable the sustainable development of the social economy.

6.2. Limitations and Future Research Directions

Based on the intellectual property regulation policy, this paper reveals the main reasons for the frequent occurrence of infringement events. It proposes the optimal solution to achieve the expected goal of policy regulation, but also has some limitations. In order to simplify the analysis process, this paper does not include the innovation rewards of enterprises as a direct variable in the solution of the model, and the behavior subjects are limited to the government and infringers. This paper also does not analyze the behavior of the property holders in the category of intellectual property. Inspired by previous research [23,42], in the future, the intellectual property holders can be introduced into the research as a game player, and the government subsidy can be included in the model as an influencing variable. Thus, the dual subject game can be expanded into a multi-agent non-cooperative game. According to the interest game relationship between local government regulators, intellectual property infringers, and holders, we will explore the behavioral interaction mechanism of these three game players.

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References

1. Rivette, K.G.; Kline, D. Discovering New Value in Intellectual Property. *Harvard Bus. Rev.* **2000**, *78*, 54–66.
2. Zheng, Y. Research on Punitive Damages System of Intellectual Property Infringement. *Enterp. Reform Manag.* **2020**, *28*, 3–4.
3. Annual Report of the Intellectual Property Court of the Supreme People's Court. 2021. Available online: https://www.court.gov.cn/zixun-xiangqing-347361.html (accessed on 15 March 2022).
4. Annual Report of the Intellectual Property Court of the Supreme People's Court. 2020. Available online: http://www.court.gov.cn/zixun-xiangqing-288081.html (accessed on 11 November 2021).
5. Ye, Q.; Li, Q. On the Government's Measures against Trademark Infringement Based on an Evolutionary Game Model. *Chin. Public Admin.* **2009**, *25*, 69–72.
6. Liu, X.; Bao, X. Intellectual Property Information Disclosure and Value Relevance of Listed Companies. *Sci. Technol. Manag. Res.* **2020**, *40*, 218–222.
7. Li, X.; Yuan, X. Research on the Punitive Damages Award System of Patent Infringements in U.S. and Implications. *Sci. Technol. Manag. Res.* **2016**, *36*, 160–164.
8. Zhu, J.; Xu, L. On the Construction of the Intellectual Property Protection Evaluation System. *Intellect. Prop.* **2021**, *35*, 52–67.
9. Kanwar, S.; Evenson, R. On the Strength of Intellectual Property Protection That Nations Provide. *J. Dev. Econ.* **2009**, *1*, 50–56. [CrossRef]
10. Grossman, G.A.; Lai, E.L.C. International Protection of Intellectual Property. *Am. Econ. Rev.* **2004**, *94*, 1635–1653. [CrossRef]
11. Du, R.; Liu, B. Cultivating Intellectual Property Cultural Awareness by Analyzing Groups' Infringement. *Hebei Law Sci.* **2010**, *28*, 160–164.
12. Cui, X. An Analysis of Legal System of Advertising from the Perspective of the Intellectual Property Strategy. *Guangxi Soc. Sci.* **2010**, *26*, 59–63.
13. Zhang, F.; Cai, H. Software Piracy: A Game Analysis between Firm's Strategic Choice and Government Policy. *J. Ind. Eng. Eng. Manag.* **2005**, *19*, 94–98.
14. Banerjee, D.S.; Banerjee, T.; Raychaudhuri, A. Optimal Enforcement and Anti-copying Strategies to Counter Copyright Infringement. *Jpn. Econ. Rev.* **2008**, *59*, 519–535. [CrossRef]
15. Yi, J. On the Risk and Countermeasures of Intellectual Property Infringement Confronting Cross-Border E-Commerce: Taking Chinese E-Merchants Sued in the US as an Illustration. *Intellect. Prop.* **2021**, *35*, 36–53.
16. Basu, K. Civil Institutions and Evolution: Concepts, Critique and Models. *J. Dev. Econ.* **1995**, *46*, 19. [CrossRef]
17. Kosfeld, M. Why Shops Close Again: An evolutionary Perspective on the Deregulation of Shopping Hours. *Eur. Econ. Rev.* **2002**, *46*, 51–72. [CrossRef]
18. Hu, Z.; Huang, D. An Evolutionary Game Theory Approach for Portfolio Selection. *Syst. Eng.* **2004**, *22*, 44–49.
19. Guttman, J.M. On the Evolutionary Stability of Preferences for Reciprocity. *Eur. J. Polit. Econ.* **2000**, *16*, 31–50. [CrossRef]
20. Yang, M.; Yang, K.; Che, Y.; Lu, S.; Sun, F.; Chen, Y.; Li, M. Resolving Transboundary Water Conflicts: Dynamic Evolutionary Analysis Using an Improved GMCR Model. *Water Resour. Manag.* **2021**, *35*, 3321–3338. [CrossRef]
21. Sheng, S.; Jiang, D. *Evolutionary Economics*; Shanghai Sanlian Bookstore: Shanghai, China, 2002; pp. 281–326.
22. Zhang, S.; Yu, Y.; Zhu, Q.; Qiu, C.M.; Tian, A. Green Innovation Mode under Carbon Tax and Innovation Subsidy: An Evolutionary Game Analysis for Portfolio Policies. *Sustainability* **2020**, *12*, 1385. [CrossRef]
23. Deng, G.; Chen, J.; Liu, Q. Influence Mechanism and Evolutionary Game of Environmental Regulation on Green Port Construction. *Sustainability* **2022**, *14*, 2930. [CrossRef]
24. Gu, Q.; Hang, L.; Sun, S. Behavioral Game Theory Model in Pollution Control with Additional Supervision. *Algorithms* **2022**, *15*, 137. [CrossRef]
25. Zhou, B. Research on the Protection of Intellectual Property Law and the Mechanism of Interest Balance in the Post-civil Code Era. *Legal. Vision* **2021**, *37*, 55–56.
26. Han, N. Research on the Legal Norm of Intellectual Property in the Civil Code. *Sci. Technol. Law* **2021**, *33*, 86–95.
27. Spinello, R.A. Intellectual Property Rights. *Libr. Hi. Tech.* **2007**, *25*, 12–22. [CrossRef]
28. Li, C. System and Mechanism of China's Administrative Enforcement of Intellectual Property and the Reformation of the Same. *J. Northwest Univ. (Philos. Soc. Sci. Edit.)* **2018**, *48*, 64–74.
29. Sun, G. Some Reflections on the Standard Unity of the Administrative Enforcement and the Judicature of IPR. *China J. Appl. Juris.* **2021**, *5*, 86–99.

30. Marlyna, H.; Sardjono, A. Does the Trademark Protection Regulation Protect Consumers Against Counterfeit Products? Analyzing the Theories of Trademark and Indonesian Trademark Law. *Pertanika J. Soc. Sci. Hum.* **2019**, *27*, 1865–1877.
31. Cao, X.; Cui, F. An Empirical Study on the Discretionary Rule of Damages in Intellectual Property Infringement. *Jiangsu Soc. Sci.* **2017**, *38*, 120–131.
32. Liu, J.; Hu, Y.; Wang, F. A Model for Evaluating the Influence Factors in Trademark Infringement Based on Fuzzy Analytical Hierarchy Process. *J. Intell. Fuzzy Syst.* **2020**, *38*, 6777–6784. [CrossRef]
33. Zhang, K. The Perfection of the System of Compensation for Infringement of Intellectual Property Rights. *Legal Syst. Soc.* **2021**, *30*, 163–164.
34. Chávez-Angeles, M.G.; Sánchez-Medina, P.S. Application of the War of Attrition Game to the Analysis of Intellectual Property Disputes. *arXiv* **2015**, arXiv:150402511. Available online: https://arxiv.org/abs/1504.02511 (accessed on 20 December 2021).
35. Lis-Gutiérrez, J.P.; Sarmiento, Á.Z.; Viloria, A. Intellectual Property in Colombian Museums: An Application of Machine Learning. In Proceedings of the 9th International Conference on Intelligence Science and Big Data Engineering, Nanjing, China, 11–17 October 2019; pp. 289–301.
36. Jeong, H.; Kwak, J. Automated Detection Technique for Suspected Copyright Infringement Sites. *KSII T. Internet Inf.* **2020**, *14*, 4889–4908.
37. Endah, S.N.; Adhy, S. Integrated System Design for Broadcast Program Infringement Detection. *Telkomnika* **2015**, *13*, 571–577. [CrossRef]
38. Hung, K.; Chen, L.; Chen, T. Trademark Infringement Recognition Assistance System Based on Human Visual Gestalt Psychology and Trademark Design. *Eurasip J. Image Video Processing* **2021**, *1*, 1–18. [CrossRef]
39. Li, J.; Xu, C.; Huang, L. Evolutionary Game Analysis of the Social Co-governance of E-Commerce Intellectual Property Protection. *Front. Psychol.* **2002**, *13*, 832743. [CrossRef]
40. Takeyama, L.N. The Welfare Implications of Unauthorized Reproduction of Intellectual Property in the Presence of Demand Network Externalities. *J. Ind. Econ.* **1994**, *42*, 155–166. [CrossRef]
41. Chen, Y.; Png, I.P.L. Software Pricing and Copyright: Enforcement against End-Users. 17 June 1999. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=165228 (accessed on 25 March 2022).
42. Crampes, C.; Langinier, C. Litigation and Settlement in Patent Infringement Cases. *RAND J. Econ.* **2002**, *33*, 258–274. [CrossRef]
43. Phelps, M.P.F. Avoiding Patent Infringement. *Mach. Des.* **2019**, *91*, 30–32.
44. Weibull, J.W. *Evolutionary Game Theory*; Princeton Press: Princeton, NJ, USA, 1995; pp. 44–55.
45. Friedman, D. Evolutionary Games in Economics. *Econometrica* **1991**, *59*, 637–666. [CrossRef]
46. Yang, Z.; Liu, B. Evolutionary Game Research on the Diffusion of Green Innovation of Domestic and Foreign Enterprises under Government Control. *Soft Sci.* **2019**, *33*, 86–91.
47. Bian, R. On the Standard, Dilemma, and Reconstruction of the Rules in Relation to Patent Infringement Damages. *Intellect. Prop.* **2021**, *36*, 34–53.
48. Liu, J. Economic Policy Uncertainty, Government Subsidies and Enterprise Innovation. *Stat. Decis.* **2022**, *38*, 169–174.
49. Yu, X.; Xu, Y.; Zhang, J.; Sun, Y. The Synergy Green Innovation Effect of Green Innovation Subsidies and Carbon Taxes. *Sustainability* **2022**, *14*, 3453. [CrossRef]