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The Tripartite Evolutionary Game of Intellectual Property Protection with Government Participation

Xiyu Ma

University of East Anglia, Norwich, UK
Email: Larch1027@163.com

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Abstract

As society continues to develop, intellectual property rights are becoming more and more important and play an important role in promoting economic development and other aspects. Intellectual property rights are not only important for enterprises, but also indispensable for the existence of government work. Based on the theoretical framework of evolutionary game, this paper constructs a three-party game model with the government, innovation subjects and stealers as the main players, analyzes the evolutionary stabilization strategies of each participant, and conducts numerical simulations on this basis to further explore the key influencing factors of government administrative punishment, subsidies and the cost of innovation subjects in defending their rights. The results show that the three parties of the game reach strategic equilibrium when the innovative subject chooses to defend its rights, the government chooses to conduct strict regulation strategy, and the stealer chooses to conduct infringement behavior. For the influence of key factors, when the administrative penalties charged by the government for infringement increase and the subsidies to innovative subjects increase, it will lead to an increase in the probability of enterprises to defend their rights and a decrease in the probability of stealers to infringe; while the increase in the cost of innovative subjects suffering from infringement at the time of defense will lead to a decrease in the probability of innovative subjects to defend their rights and an increase in the probability of stealers to infringe.

Keywords

Intellectual Property Rights, Tripartite Evolutionary Game, Simulation Analysis, Government Involvement

1. Introduction

Nowadays, with the continuous development of society, intellectual property rights have gradually become more and more intimate with people's lives, and play an important role in promoting economic development, technological progress and cultural prosperity. But at the same time, there are many disputes involving intellectual property rights at home and abroad. If an enterprise invests a lot of human, material and financial resources in the development of new products, if it does not effectively protect its intellectual property rights, other rivals will participate in the market competition through plagiarism and other improper means, which will cause considerable damage to the enterprise's innovation. As a special kind of intangible property, Liu (2012) argues that it is characterized as legal and terminable. At the same time, IPR disputes are also characterized by overlapping disputes and unpredictable outcomes (Liu, 2012). And in terms of time, the development process of IPRs is a development process that is constantly updated with the times, and as it continues to evolve, the progress of IPRs likewise drives the progress of society, as Oguamanam (2010) argues that IPRs are a driving mechanism that rewards and motivates the market for promoting innovation and stimulating creativity (Oguamanam, 2010). With the advancement of IPRs, there has been a growing awareness of the importance of IPRs for the development of society, and therefore a lot of research has been done in this area. 2013 Willoughby's analysis of the biotechnology industry found a significant positive correlation between firms' investment in IPRs and firm performance (Willoughby, 2013). Ahangar (2011), in his analysis of Iranian firms, found that the intellectual capital of firms is beneficial for their profitability, production and sales. In addition to this, some scholars have concluded that intellectual property protection and innovation are complementary after empirical studies on developing countries. For example, Hudson and Minea (2013) found that the strength of the effect of IPRs on innovation depends on the GDP per capita of each country, and also pointed out that in developing countries, where the protection of IPRs is relatively weak due to rapid economic development, strengthening the protection of IPRs would be a great boost to technological innovation in firms (Hudson & Minea, 2013). Mehta et al. (2014) argued that knowledge as a strategic resource can provide a sustainable competitive advantage and is the basis for a firm's products and services. In order to remain competitive, firms must find better ways to manage their knowledge resources (Mehta et al., 2014). Therefore, it can be seen that the issue of intellectual property protection is also very important for companies. Its practical value lies in the fact that it can be considered as a special asset of the company, in the form of a patent, as an essential element of the company's operational strategy. And for knowledge-intensive companies, the management of intellectual property creation is one of the core elements of the company's strategy (Kimble et al., 2016). In addition, IP is not only important for companies, but also indispensable for government work, which is not only promoted by the government to develop

well, but also in turn can promote the work of the government for the betterment of the society. Zaied et al. (2012) examined the integration of IP management and government policy and found that the elements that constitute IP management capabilities all contribute to the utility of government organizations and that there is a strong correlation between the two. 2017's 13th Five-Year Plan for the Protection and Use of National Intellectual Property Rights included IPRs in the special protection plan, and since then, after several years of development, Li and Xu (2022) suggest that despite the influence of Despite the impact of COVID-19, the market has seen significant development opportunities. At the same time, the level of IPR protection in China has been improving (Li & Xu, 2022). Although the level of IPR protection in China is in continuous development, there are still certain problems in the research of IPR issues, and the current research and theory as well as practice, etc. are weak. In the field of economics, most economic problems can be abstracted as an interactive process in which multiple rational people make decisions to maximize their own returns, and game theory provides a sophisticated theoretical framework for dealing with this two-sided decision process (Cheng, 2014). The government's behavioral strategies also have an impact (Gu & Hang, 2022), such as government subsidies, administrative penalties, and other factors. The same theoretical framework, this article is based on evolutionary game is constructed, innovators and stealer government as the main participants in the tripartite game model, analysis the strategy of the parties and the evolutionary stable strategy of each participant, and has carried on the numerical simulation on the basis of this, further study on the government administrative punishment, subsidies, and the key factors that affect the cost of innovators' rights, key factors affecting the cost of intellectual property protection. Some suggestions are put forward to strengthen the protection of intellectual property rights.

2. Basic Assumptions and Model Construction

1) Basic assumptions

In order to construct a game model and analyze the strategies of each party and the influence relationship of each element, the following hypotheses are made in this paper.

Hypothesis 1: The innovation subject as participant 1, the government as participant 2, and the stealer as participant 3. All three parties are finite rational participant subjects, and the strategy choice evolves gradually over time to stabilize the optimal strategy.

Hypothesis 2: The strategy space $\alpha = (\alpha_1, \alpha_2)$ = (defend rights, do not defend rights) for the innovation subject and choose α_1 with probability x and α_2 with probability $(1 - x)$; the strategy space $\beta = (\beta_1, \beta_2)$ = (strict regulation, lax regulation) for the government and choose β_1 with probability y and β_2 with probability $(1 - y)$; the strategy space $\gamma = (\gamma_1, \gamma_2)$ for the stealer = (infringement, non-infringement) and choose γ_1 with probability of z and γ_2 with probability of

$(1-z)$. Where x, y and z belong to [0, 1].

Hypothesis 3: For the innovation subject, it is assumed that the enterprise innovation subject can get S_1 units of government subsidies and preferential policies, needs to pay C_3 units of innovation cost, and can get W_1 units of revenue without infringement. When the innovation subject suffers from infringement, it will suffer losses of L units, and the innovation subject will pay C_4 units of the cost of defending the right, and after defending the right, it may bring M units of reputation and expectation, etc. and F_2 units of compensation for the innovation subject. And the innovation subject will pay H units of cost for patent application when defending the right. For the government, in strict regulation and lax regulation innovation subject due to innovation brought R_1 and R_2 units of total social benefits, respectively, the government in lax mode due to improper regulation caused by S_2 units of credit loss, etc., the government will charge F_1 units of administrative penalties for infringement, in the government strict and lax regulation need to pay C_1 and C_2 units of regulatory costs. For the stealer, the choice of infringement brings a gain of W_2 units.

2) Payment Matrix

Based on the above assumptions, the mixed strategy payment matrix for innovation agents, stealers and government is shown in Table 1.

In the tripartite game between the innovator, the stealer and the government, the innovator enjoys the benefits of ownership and bears the corresponding costs of innovation. The stealer has the opportunistic behavior of "free-riding" and also bears the corresponding penalties if the right is successfully defended. It is difficult for the government to intervene directly in the infringement process because of the cost and effort of strict government regulation and the difficulties of effective government regulation due to the widespread information asymmetry.

Table 1. Mixed strategy game matrix of innovation agents, stealers and government.

Game Players				Government	
				Strict regulation (y)	Loose regulation $(1-y)$
Innovation subject	Defending Rights (x)	Stealers	Infringement (z)	$W_1+S_1+F_2-C_3-C_4$ $+M-L-H$ $W_2-F_1-F_2$ $R_1-S_1+F_1-C_1$	$W_1+S_1+F_2-C_3-C_4$ $+M-L-H$ $W_2-F_1-F_2$ $R_2-S_1-S_2-C_2+F_1$
			Non-infringement $(1-z)$	$W_1+S_1-C_3-H$ 0 $R_1-S_1-C_1$	$W_1+S_1-C_3-H$ 0 $R_2-S_1-C_2$
	No rights defense $(1-x)$	Stealers	Infringement (z)	$W_1+S_1-C_3-L$ W_2-F_1 $R_1-S_1+F_1-C_1$	$W_1+S_1-C_3-L$ W_2-F_1 $R_2-S_1-S_2-C_2+F_1$
			Non-infringement $(1-z)$	$W_1+S_1-C_3$ 0 $R_1-S_1-C_1$	$W_1+S_1-C_3$ 0 $R_2-S_1-C_2$

In other words, there is an evolutionarily stable strategy, that is, a strategic equilibrium, for the three of rights protection, strict regulation and infringement. Whenever one of the factors changes, the other two will be followed by corresponding changes so as to maintain the balance between the three. In other words, there is an evolutionarily stable strategy, that is, a strategic equilibrium, for the three of rights protection, strict regulation and infringement. Whenever one of the factors changes, the other two will be followed by corresponding changes so as to maintain the balance between the three. For example, the more infringement cases, the more people will defend their rights, so the government's supervision will become more strict. For example, the more infringement cases, the more people will defend their rights, so the government's supervision will become more strict. In the tripartite game among the innovator, the stealer and the government, according to the basic assumptions of the model, the different strategies of the three parties are calculated to form a payment matrix, see **Table 1**, in which, when the stealer chooses not to infringe, the whole process of "infringement-violation" does not occur, and the stealer has neither the relevant benefits nor the relevant costs. At this point, whether the government chooses to strictly regulate or loosely regulate, it needs to pay a certain amount of regulatory costs and subsidies, and correspondingly obtain a certain amount of total social benefits (Xu, 2017).

3) Replication of dynamic equations

The evolutionary game is based on the derivation of the replication dynamic equations of the game participants through the expected payoffs of the payment matrix. According to the Malthusian equation, the expected payoffs and the average expected payoffs of innovative agents choosing to defend their rights and not to defend their rights are collapsed and combined as

$$\begin{cases} E_{11} = z\left(F_2 - C_4 + M - L\right) + W_1 + S_1 - C_3 - H \\ E_{12} = W_1 + S_1 - C_3 - z\left(W_1 + S_1 - C_3 + L\right) \\ \bar{E}_1 = xE_{11} + \left(1-x\right)E_{12} \end{cases}$$

The replication dynamic equation for the strategy choice of the innovation subject is.

$$\begin{aligned} F\left(x\right) &= \mathrm{d}x/\mathrm{d}t = \left(E_{11} - E_{12}\right)\left(1-x\right)x \\ &= \left[z\left(F_2 - C_4 + M + W_1 + S_1 - C_3\right) - H\right]\left(1-x\right)x \end{aligned}$$

The expected returns as well as the average expected returns for the government's choice of strict and lax regulation are collapsed and combined as follows.

$$\begin{cases} E_{21} = zF_1 + R_1 - S_1 - C_1 \\ E_{22} = z\left(F_1 - S_2\right) + R_2 - S_1 - C_2 \\ \bar{E}_2 = yE_{21} + \left(1-y\right)E_{22} \end{cases}$$

The replication dynamic equation for government strategy choice is

$$\begin{aligned} F\left(y\right) &= \mathrm{d}y/\mathrm{d}t = \left(E_{21} - E_{22}\right)\left(1-y\right)y \\ &= \left(zF_2 + R_1 - R_2 - C_1 + C_2\right)\left(1-y\right)y \end{aligned}$$

The expected benefits of the stealer's choice of infringement versus non-infringement and the average expected benefits were collapsed and combined as

$$\begin{cases} E_{31} = -xF_2 + W_2 - F_1 \\ E_{32} = 0 \\ \overline{E}_3 = zE_{31} + (1-z)E_{32} \end{cases}$$

The replication dynamic equation for the stealer's strategy choice is

$$\begin{aligned} F(z) &= \mathrm{d}z/\mathrm{d}t = (E_{31} - E_{32})(1-z)z \\ &= (-xF_2 + W_2 - F_1)(1-z)z \end{aligned}$$

The above three replicated dynamic equations constitute the evolutionary game (I) for the three parties. For the convenience of arithmetic, let $a = F_2$; $b = -C_4 + M + W_1 + S_1 - C_3$; $c = H$; $d = R_1 - R_2 - C_1 + C_2$; $e = W_2 - F_1$.

As a result, the three-way evolutionary game (I) can be simplified as:

$$\begin{cases} F(x) = [z(a+b) - c](1-x)x \\ F(y) = (za + d)(1-y)y \\ F(z) = (-xa + e)(1-z)z \end{cases}$$

In an asymmetric game, the evolutionary game equilibrium E is an evolutionary stable equilibrium and must be a strict Nash equilibrium, which in turn is a pure strategy equilibrium, i.e., a mixed strategy equilibrium in an asymmetric game must not be an evolutionary stable equilibrium. Therefore, according to Ritzberger and Weibull (1996), the tripartite evolutionary game in this paper discusses only the pure strategy equilibrium $E_1(0, 0, 0)$, $E_2(0, 0, 1)$, $E_3(0, 1, 0)$, $E_4(1, 0, 0)$, $E_5(1, 1, 0)$, $E_6(1, 0, 1)$, $E_7(0, 1, 1)$, and $E_8(1, 1, 1)$ points of asymptotic stability.

4) Stability analysis of the evolutionary strategy

a) Stable conditions for strategy evolution

According to the stability theorem of the replication dynamic equation, the stability strategies of the innovation subject, the stealer and the government can be analyzed by bringing the equilibrium point (x, y, z) into the three-party evolution game (I) for judgment, when $F(x) = 0$, $F'(x) < 0$, x is an evolutionary stabilization strategy. When $z = z^*$, $F(x) = 0$ is constant, indicating that all strategies are steady states and the probability of strategy selection x of the innovative subject does not change over time. When $z > z^*$, $x = 0,1$ are two strategies for innovative subjects. While $F'(0) > 0$, $F'(1) < 0$, therefore, $x = 1$ is the point of stability, indicating that the increased benefits outweigh the costs when the innovative subject chooses to carry out the maintenance of rights, and that carrying out the maintenance of rights is an evolutionary stabilization strategy. When $z < z^*$, $F'(0) < 0$, $F'(1) > 0$, therefore, $x = 0$ is the point of stability, it indicates that the benefits of the innovative subject to defend the right are less than the costs, and not to defend the right is an evolutionary stable strategy.

For stable conditions for the evolution of government strategies, let $F(y)=0$, it can be obtained that $y=0,1$, $z^*=-\frac{d}{a}$. When $z=z^*$, $F(y)=0$ holds constant, indicating that all strategies are steady states and the government strategy selection probability y does not change over time. When $z>z^*$, $y=0,1$ are two strategies of the government. While $F'(0)>0$, $F'(1)<0$, therefore, $y=1$ is the stability point, indicating that the increased benefits outweigh the costs when the government chooses to strictly regulate and that conducting strict regulation is an evolutionarily stable strategy. When $z<z^*$, $F'(0)<0$, $F'(1)>0$, so $y=0$ is the stabilization point, indicating that the benefits of strict government regulation are less than the costs, and that the absence of strict regulation is an evolutionary stabilization strategy.

For stable conditions on the evolution of the stealer's strategy, let $F(z)=0$, so $z=0,1$, $x^*=\frac{e}{a}$. When $z=z^*$, $F(z)=0$ holds constant, indicating that all strategies are steady states and the stealer strategy selection probability z does not change over time. When $x>x^*$, $z=0,1$ are the two strategies of the stealer, and $F'(0)<0$, $F'(1)>0$, therefore, $z=0$ is the stability point, indicating that the increased benefits outweigh the costs when choosing to infringe and that performing the infringement is an evolved and stable strategy. When $x<x^*$, $F'(0)>0$, $F'(1)<0$, Therefore, $z=1$ is a stable point, indicating that the benefits of the stealer performing the infringement are less than the costs, and not performing the infringement is an evolutionarily stable strategy.

b) Stability analysis of evolutionary equilibrium

According to Friedman's study, the evolutionary stable strategy (ESS) of the game can be judged by the eigenvalues λ of the Jacobian matrix. According to the Liapunov discriminant, the eigenvalue λ is all greater than zero, the equilibrium point is not stable and is the source point; the eigenvalue λ has positive and negative, the equilibrium point is the saddle point; the eigenvalue λ is all less than zero, the equilibrium point is the sink point and is also the stable point of evolution. The Jacobi matrix of the three-party evolutionary game in this paper is,

$$J=\begin{pmatrix} J_1 & J_2 & J_3 \\ J_4 & J_5 & J_6 \\ J_7 & J_8 & J_9 \end{pmatrix}=\begin{pmatrix} \partial F(x)/\partial x & \partial F(x)/\partial y & \partial F(x)/\partial z \\ \partial F(y)/\partial x & \partial F(y)/\partial y & \partial F(y)/\partial z \\ \partial F(z)/\partial x & \partial F(z)/\partial y & \partial F(z)/\partial z \end{pmatrix}$$

$$=\begin{pmatrix} \left[z(a-b)-c\right](1-2x) & 0 & (a-b)(1-x)x \\ 0 & (az+d)(1-2y) & a(1-y)y \\ -a(1-z)z & 0 & (-ax+e)(1-2z) \end{pmatrix}$$

According to the Jacobi matrix, the eigenvalues of the local equilibrium of the three-party evolutionary game are shown in Table 2.

Case 1: When $d<0$, $e<0$ and $-c<0$, the equilibrium point $E_1(0, 0, 0)$ is the evolutionary stability point of the system. At this point, the benefit of the

Table 2. Distribution of eigenvalues of local equilibrium points of the game and convergence conditions.

Balancing point	Eigenvalue			Convergence stability conditions
	λ_1	λ_2	λ_3	
$E_1(0, 0, 0)$	d	e	$-c$	$d<0$, $e<0$, $-c<0$
$E_2(0, 0, 1)$	$a+d$	$-e$	$a-b-c$	$a+d<0$, $-e<0$, $a-b-c<0$
$E_3(0, 1, 0)$	e	$-c$	$-d$	$e<0$, $-c<0$, $-d<0$
$E_4(1, 0, 0)$	c	d	$e-a$	$c<0$, $d<0$, $e-a<0$
$E_5(1, 1, 0)$	c	$e-a$	$-d$	$c<0$, $e-a<0$, $-d<0$
$E_6(1, 0, 1)$	$a+d$	$a-e$	$b-a+c$	$a+d<0$, $a-e<0$, $b-a+c<0$
$E_7(0, 1, 1)$	$-e$	$-a-d$	$a-b-c$	$-e<0$, $-a-d<0$, $a-b-c<0$
$E_8(1, 1, 1)$	$a-e$	$-a-d$	$b-a+c$	$a-e<0$, $-a-d<0$, $b-a+c<0$

innovation subject to defend the right is less than the cost, so it chooses not to defend the right; the benefit of the government to carry out strict regulation is less than the cost, so it chooses lax regulation; the benefit of the stealer to carry out infringement is less than the cost, so it chooses not to infringe.

Case 2: When $a+d<0$, $-e<0$ and $a-b-c<0$, the equilibrium point $E_2(0, 0, 1)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is less than the cost, so it chooses not to defend the right; the benefit of the government to carry out strict regulation is less than the cost, so it chooses lax regulation; the benefit of the stealer to carry out infringement is greater than the cost, so it chooses infringement. Case 2: When $a+d<0$, $-e<0$ and $a-b-c<0$, the equilibrium point $E_2(0, 0, 1)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is less than the cost, so it chooses not to defend the right; the benefit of the government to carry out strict regulation is less than the cost, so it chooses lax regulation; the benefit of the stealer to carry out infringement is greater than the cost, so it chooses infringement.

Case 3: When $e<0$, $-c<0$ and $-d<0$, the equilibrium point $E_3(0, 1, 0)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is less than the cost, so it chooses not to defend the right; the benefit of the government to carry out strict regulation is greater than the cost, so it chooses strict regulation; the benefit of the stealer to carry out infringement is less than the cost, so it chooses not to infringe.

Case 4: When $c<0$, $d<0$ and $e-a<0$, the equilibrium point $E_4(1, 0, 0)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is greater than the cost, so it chooses to do so; the benefit of the government to carry out strict regulation is less than the cost, so it chooses lax regulation; the benefit of the stealer to carry out infringement is less than the cost, so it chooses not to infringe.

Case 5: When $c < 0$, $e - a < 0$ and $-d < 0$, the equilibrium point $E_5(1, 1, 0)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is greater than the cost, so it chooses to defend the right; the benefit of the government to carry out strict regulation is greater than the cost, so it chooses strict regulation; the benefit of the stealer to carry out infringement is less than the cost, so it chooses not to infringe.

Case 6: When $a + d < 0$, $a - e < 0$ and $b - a + c < 0$, the equilibrium point $E_6(1, 0, 1)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is greater than the cost, so it chooses to carry out the right; the benefit of the government to carry out strict regulation is less than the cost, so it chooses lax regulation; the benefit of the stealer to carry out infringement is greater than the cost, so it chooses infringement.

Case 7: When $-e < 0$, $-a - d < 0$ and $a - b - c < 0$, the equilibrium point $E_7(0, 1, 1)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is less than the cost, so it chooses not to defend the right; the benefit of the government to carry out strict regulation is greater than the cost, so it chooses strict regulation; the benefit of the stealer to carry out infringement is greater than the cost, so it chooses infringement.

Case 8: When $a - e < 0$, $-a - d < 0$ and $b - a + c < 0$, $E_8(1, 1, 1)$ is the evolutionary stability point of the system. At this point, the benefit of the innovation subject to defend the right is greater than the cost, so choose to carry out the right; the benefit of the government to carry out strict regulation is greater than the cost, so choose strict regulation; the benefit of the stealer to carry out infringement is greater than the cost, so choose infringement.

3. Evolutionary Path Simulation

In order to verify the validity of the evolutionary stability analysis, the model is numerically assigned to a realistic situation and a numerical simulation is performed using Matlab 2020b to explore the ideal equilibrium path of game evolution.

1) Baseline evolutionary path simulation

In order to set the baseline parameters, the variable parameters of the model need to satisfy the economic assumptions and empirical judgments, and the baseline values of the model parameters are set based on objective facts and the experience of previous studies. The initial values of each parameter involved in this paper are shown in **Table 3**.

According to the initial value settings of each parameter given above, the benchmark evolutionary results are shown in **Figure 1**. From the figure, it can be seen that there is an evolutionary stable strategy in the three-party game among the innovation subject, the government and the stealer, i.e., a strategic equilibrium of (rights defense, strict regulation, and infringement). The evolutionary equilibrium of the benchmark simulation shows that usually the innovation subject prefers to carry out the rights defense procedure, the government

Table 3. Initial values of the parameters in the model of earnings of each economic agent of the reinsurance.

Related parameters	Parameter Meaning	Set initial value
R_1	The total social benefits brought by innovation subject under strict government supervision	12
R_2	The overall benefits of innovation in the government's loose regulation are the social benefits of innovation	6
S_1	The government's subsidies and preferential policies for innovation main innovation	3
S_2	The government in the loose mode due to improper supervision caused by credit losses	6
F_1	The administrative penalty charged by the government for an infringement	2
F_2	The compensation that the innovation subject can obtain after rights protection	7
C_1	The regulatory cost required by the government under strict government supervision	7
C_2	The cost of government regulation under light government regulation	4
C_3	Innovation cost of innovation subject	5
C_4	The cost of rights protection when the innovation subject suffers infringement, such as legal costs	7
M	The reputation and good expectation that the innovation subject can bring after the success of rights protection	2
W_1	The profit before innovation subject is free from infringement	10
W_2	The proceeds of the thief's infringement	15
L	The loss suffered by the innovation subject in the process of infringement	8
H	The cost required by the innovation subject to apply for a patent when safeguarding its rights, such as commission, etc	1

correspondingly prefers to carry out the strict regulation strategy, and the stealer also chooses to carry out the infringement behavior. The strategic choices of the three will reach an evolutionary equilibrium.

2) Simulation of the evolution of the influence effect of key factors

Based on the results of the evolution of the benchmark simulation, it is necessary for this paper to examine the mechanism of the influence of the administrative penalties charged by the government for the infringement, the subsidies and preferential policies carried out by the government for the innovation of the innovative subject, etc. and the cost of the innovative subject suffering from the

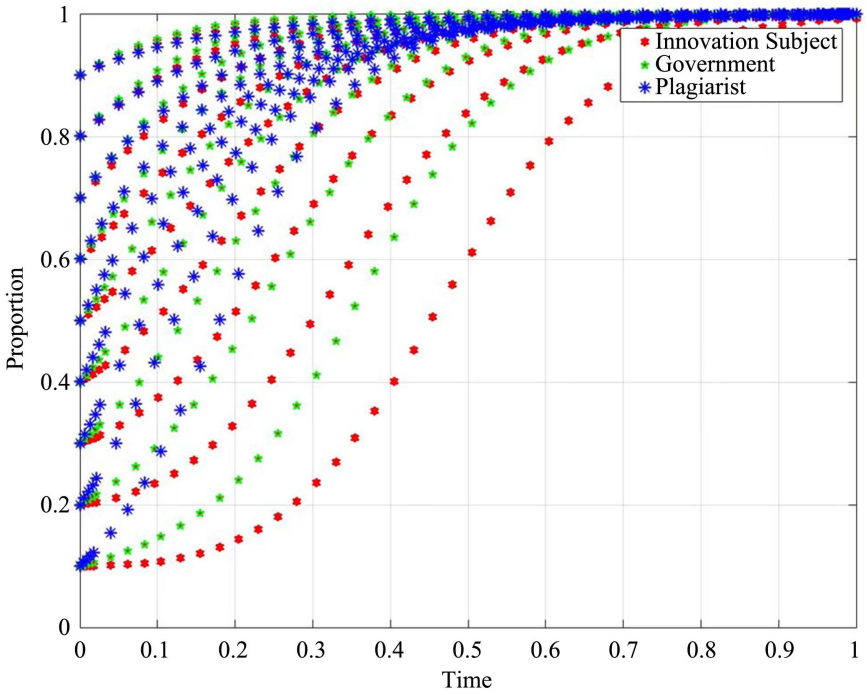

Figure 1. Basic evolutionary equilibrium simulation.

infringement in defending its rights on the evolution of the game in order to examine the path of achieving the stable equilibrium point.

a) The impact of administrative penalties charged by the government for violations on the game equilibrium

To facilitate the observation of the impact of the administrative penalty charged by the government for infringement on the game equilibrium, the parameters of each economic agent in this paper are assumed to be consistent with Table 3 except for the administrative penalty F1 charged by the government for infringement. The resulting equilibrium game of the innovation subject, the government and the stealer is shown in Figure 2. As can be seen from the figure, as the administrative penalty charged by the government for infringement increases, the probability of enterprises to defend their rights increases, the probability of stealers to infringe decreases, and the government is more inclined to the strategy of strict regulation. Therefore, increasing the administrative penalties charged by the government for infringement is conducive to reducing the probability of infringement and thus ultimately beneficial to the protection of intellectual property rights.

b) The impact of government subsidies and incentives on innovation of innovation agents on the game equilibrium

In order to facilitate the observation of the impact of government subsidies and preferential policies, etc. on innovation of innovation subjects on the game equilibrium, the parameters of each economic subject in this paper are assumed to be consistent with Table 3 except for S_1 of government subsidies and

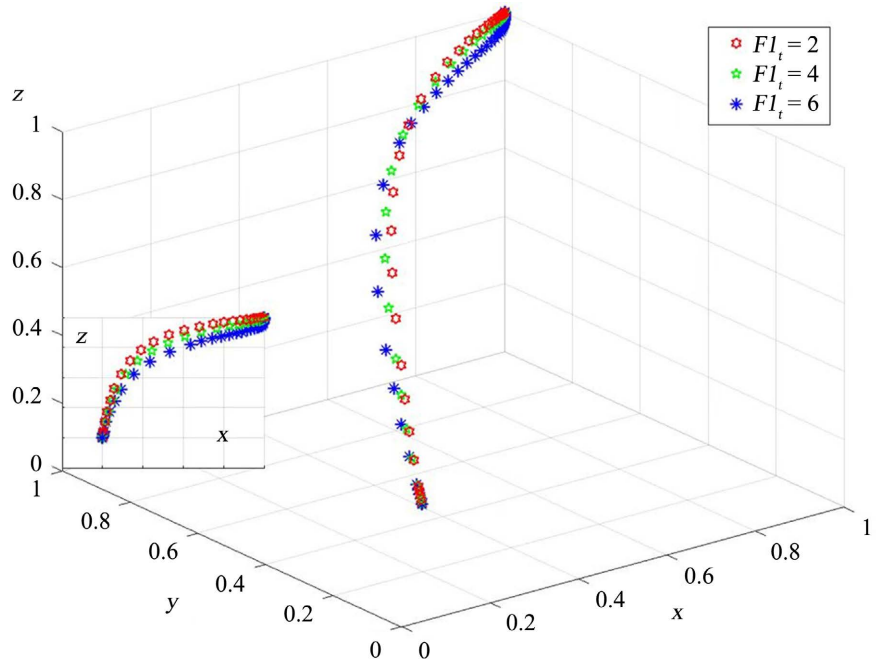

Figure 2. Impact of administrative penalties charged by the government for violations.

preferential policies, etc. on innovation of innovation subjects. The resulting equilibrium game of innovation subject, government and stealer is shown in Figure 3. It can be seen from the figure that as the government's subsidies and preferential policies for innovation subjects increase, the probability of innovation subjects choosing to defend their rights increases and the probability of stealers choosing to infringe decreases, but the government will reduce the probability for strict regulation. Therefore, the government's subsidies and preferential policies for innovative subjects are helpful to protect innovative subjects and reduce the probability of infringement, but the government needs to control the strength of subsidies, too many subsidies may also bring negative effects, in addition to raising taxation, there may be a cover-up of the operational losses of innovative subjects, making the failure of the business mechanism.

c) The impact of the cost of infringement on the game equilibrium when the innovation subject suffers from infringement

In order to facilitate the observation of the impact of the cost of the innovation subject suffering from infringement in defending the right on the equilibrium of the game, the parameters of each economic subject in this paper are assumed to be consistent with Table 3 except for the cost of the innovation subject suffering from infringement in defending the right C_4. The equilibrium game of the innovation subject, the government and the stealer is shown in Figure 4. It can be seen from the figure that, as the cost of infringement to the innovation subject increases, the probability of infringement by the innovation subject decreases, the probability of infringement by the stealer increases, and the government will be more inclined to choose strict regulation. Therefore, the

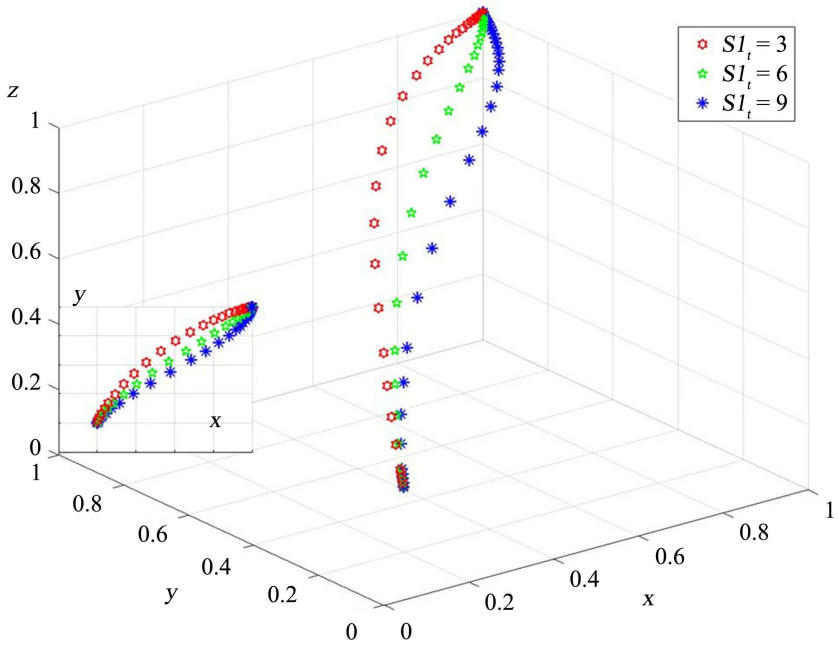

Figure 3. Impact of government subsidies and incentives, etc. on innovation by innovation agents.

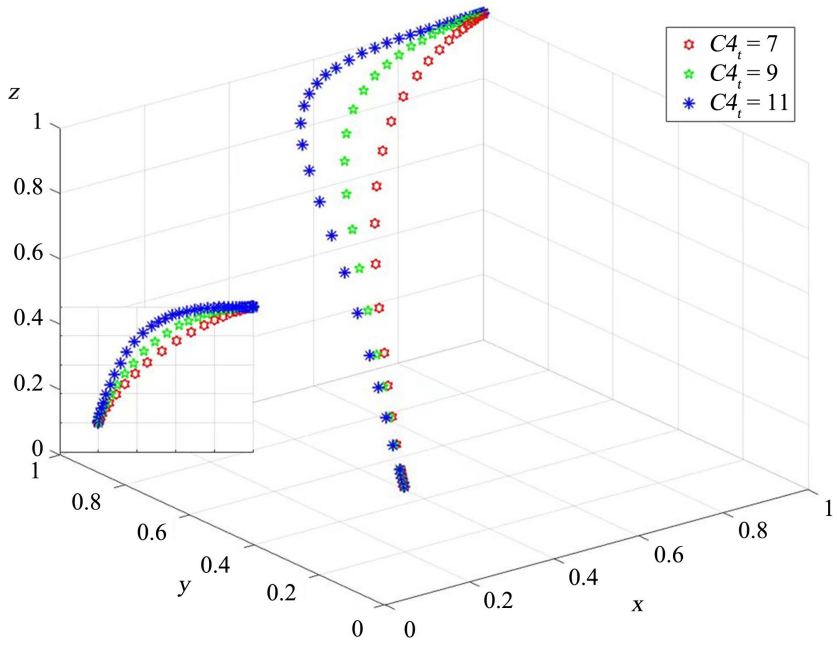

Figure 4. Impact of infringement on the cost of defending the rights of innovative subjects.

government, including the judiciary and other departments, reduces the cost of innovative subjects in defending their rights, such as shortening the processing time and reducing the time cost; exempting litigation fees and other costs are also beneficial for innovative subjects to carry out the act of defending their rights, so that the stealers can reduce the probability of infringement.

4. Conclusions and Recommendations

This paper constructs a three-party game model of government, innovation subject, and stealer based on the evolutionary game theoretical framework, explores the stability of each party's strategy choice, and uses numerical simulation to analyze the impact of each parameter change on the evolutionary path. The results show that: The three parties of the game will reach an evolutionary equilibrium in (rights protection, strict control, and infringement), i.e., usually innovative subjects will tend to carry out rights protection, while the increase of the amount of administrative punishment by the government for infringement will lead to an increase of the probability of enterprises' rights protection and a decrease of the probability of infringers' infringement by theft, so the government will prefer to implement the strategy of strict control; the increase in government subsidies and preferential policies for innovative subjects will lead to an increase in the probability of the innovative subjects to choose to defend their rights and a decrease in the probability of the stealers to choose to infringe their rights. The increase of government subsidies and preferential policies for innovative subjects will lead to an increase in the probability of innovative subjects choosing to defend their rights and an increase in the probability of thieves choosing to infringe, but the government will reduce the probability of strict regulation; and the increase of the cost of infringement suffered by innovative subjects in defending their rights will lead to a decrease in the probability of innovative subjects defending their rights and an increase in the probability of thieves infringing, while the government will prefer strict regulation.

In order to be able to better protect intellectual property rights, the following suggestions are put forward in combination with the above conclusions: 1) Increase the punishment for infringement and raise the cost of infringement, so as to effectively inhibit infringement; 2) Appropriately subsidize and reward innovation subjects, and provide certain subsidies to innovation subjects according to the actual local situation, and can appropriately provide tax relief for these innovation subjects to promote the development of innovation subjects; 3) Relax the restrictions on the rights of the innovation subjects, reduce the costs of the rights, especially for the difficult innovation subjects, open a green channel to shorten the process of the rights, reduce the time cost, extend the judicial service function, optimize the business environment, so as to reduce the burden of the innovation subjects.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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