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Research Article

Independent Innovation Incentive Mechanism of the National Independent Innovation Demonstration Zone of China Based on Evolutionary Game

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Considering the reward and punishment mechanism of the management committee and the complexity of innovation path selection of high-tech and general enterprises, this paper constructs an evolutionary game model of independent innovation incentive mechanism in the National Independent Innovation Demonstration Zone of China. Meanwhile, the equilibrium points of the strategy selection are solved for the three. In addition, this paper adopts numerical simulation to analyze the influence of each decision variable on different players' strategic selections. The results show that (1) the initial willingness of the management committee, high-tech and general enterprises has different influences on each other, and these factors such as independent innovation cost, technology spillover coefficient, and patent royalty significantly affect the strategic selection of enterprises; (2) the reward and punishment mechanism of the management committee can enhance the innovation willingness of high-tech and general enterprises, in which these punitive measures can promote further the independent innovation of the two; (3) the greater the innovation subsidy provided by the management committee to high-tech enterprises, the heavier the punishment for general enterprises, and the better the effect of independent innovation incentives. The results can provide theoretical guidance and practical reference for the management committee to formulate the independent innovation incentive policies in the National Independent Innovation Demonstration Zone.

1. Introduction

In recent years, China's economy has gradually shifted from extensive growth to intensive development, entering a new stage of high-quality development [1]. Meanwhile, the improvement of independent innovation capability has received more and more attention in this complex international development situation. The realization of innovation-driven development has become an inevitable choice for China's economic and social development. The National Independent Innovation Demonstration Zone ("the demonstration zones" for short), as test fields for China's innovation reform [2], not only play a leading role in independent innovation but also play an irreplaceable role in high-quality economic development [3].

The demonstration zones have implemented various incentive regulation measures to encourage enterprises to carry out independent innovation, such as R&D funding, financial subsidies, tax relief, and unique rewards [4]. However, the results have not met expectations [5]. Due to the characteristics of a long cycle, large investment, and high risk of independent innovation [6], some enterprises hope to benefit from imitating the advanced technology of developed countries [7]. As a result, there is a large gap between the supervision efficiency of the management committee and the actual independent innovation level of enterprises and the expectations. At present, Chinese enterprises have adopted catch-up strategies intertwined with imitative innovation and independent innovation in an increasingly competitive market environment [8, 9], which makes them face unprecedented challenges [10]. Since the management committee, high-tech and general enterprises have different interest goals, and there are mutual games in promoting independent innovation, it affects the independent innovation performance and the rapid development of the zones. Owing to the relatively short construction time of the demonstration zones, the research on how the management committee can actively encourage enterprises to participate in independent innovation is still in the exploratory stage. Improving the efficiency of incentive regulation and easing the game relationship between participants has become an important research topic.

Incentive regulation is the key to enhancing the innovation initiative of enterprises. Although enterprises have significant risks in implementing innovation, incentives still provide them with opportunities to achieve technological breakthroughs. The government adopts fiscal and tax incentive policies (such as financial subsidies and tax incentives) to encourage enterprises to increase investment in independent innovation and accelerate the transformation of independent innovation achievements and the production of new products [11]. However, when the government invests too much capital in independent innovation activities, the financing behavior of enterprises will deviate in line with the principle of market efficiency. It will also weaken the incentive effect of financial support [12, 13]. Generally speaking, independent innovation is more conducive to long-term development for high-tech enterprises. However, general enterprises have a lower innovation willingness and a greater risk of R&D failure [14]. Therefore, general enterprises acquire technology by purchasing patents or cooperating with more robust innovation companies. Furthermore, "free-riding" behaviors [15, 16] will occur in the process of cooperation between enterprises because of the significant technological differences and technology spillovers [17]. In addition, an enterprise may abandon independent innovation as a result of problems such as technology, capital, and the low probability of success. The other may also choose to wait for imitative innovation for the same reason. The result is that the innovation activities of enterprises will be stagnant, and the cooperation between enterprises will fall into trouble, which leads to the shrinking of the innovation capacity of the society.

The rest of this paper is structured as follows. In Section 2, this paper reviews the relevant literature. Section 3 explains the interactive behaviors between participants and constructs an evolutionary game model. The evolutionary stability analysis and numerical simulation analysis are conducted in Section 4 and Section 5, respectively. Conclusions and suggestions are in Section 6.

2. Literature Review

2.1. Independent and Imitative Innovation. Independent and imitative innovation are the two main R&D methods that companies follow in technology development, and the application of these two strategies is closely related to the technological accumulation level of enterprises [18], especially in R&D-intensive industries [19]. Independent innovation refers to the independent activities of enterprises to make technological breakthroughs and new product development. Imitative innovation refers to the behavior that enterprises choose to improve their technology by learning from others, such as purchasing core technology or deciphering technical secrets [20]. During the construction of the demonstration zones, independent innovation plays a crucial role in the long-term development of the enterprises and determines the work performance of the management committee. However, due to low technical levels, insufficient funds, and scarcity of innovation resources [21], some companies tend to choose imitative innovation to achieve their survival. Researchers pay attention to the impact of independent and imitative innovation on corporate performance in the existing literature [22]. For technology-intensive enterprises, independent innovation has a more significant effect on innovation activities [23]. Regarding agglomeration enterprises, moderate imitation will positively impact, and excessive imitation will negatively affect. There is an inverted U-shaped relationship between corporate and imitative innovation [24].

2.2. Impact of Incentive Regulation on Independent Innovation Performance. In the previous studies on incentive regulation, scholars have paid more attention to the effectiveness and the design of different incentive regulation strategies. Lee et al. used ordered logit regression analysis and found that R&D tax incentives, information/training, and marketing support can positively influence the independent innovation of enterprises [25]. Adler et al. adopted data envelopment analysis and second-stage regression to evaluate the impact of incentive regulation on production efficiency [26]. Shen and Lin found that policy incentives have a significant positive impact on the R&D intensity of high-tech industries based on the two-stage least square (2SLS) method [27]. The above results provide empirical evidence for the incentive regulation to promote the independent innovation of enterprises.

The government's incentive regulations mainly start from the system and economy. The institutional incentive mechanism specifically involves the formulation of laws and regulations and establishing regulatory agencies [28]. The economic incentive mechanism mainly includes bonuses [29], tax regulation [30], performance reward [31], and penalty [32]. The existing literature has achieved specific results on the incentive mechanism, including the influence mechanism and the effect of independent innovation. Brown et al. found that the improvement of accounting standards, the strengthening of contract enforcement, and intellectual property protection rights have a significant positive effect on independent innovation through comparative analysis [33]. Arbilly found that socially induced innovation can reduce the risk of independent innovation, but it may lead to lower value behaviors [34]. Pang et al. believed that subsidies, tax incentives, and government procurement could improve the overall efficiency of independent innovation [35]. In addition, strengthening the protection of intellectual property rights and reducing technological overlap between enterprises also have a significant positive effect on independent innovation [36], and the effect of government intervention on independent innovation is more pronounced [37]. Therefore, clarifying the impact and mechanism of incentive regulation is of great significance for exploring independent innovation performance in the future.

2.3. Application of Game Theory in Social Governance. Many studies take government and enterprises as the main body and construct incentive regulation models based on evolutionary game theory [38, 39]. Rocha et al. used evolutionary game and input–output analysis methods to evaluate the strategic location choices of enterprises [40]. They found a direct relationship between government incentives and regional attractiveness. Dong et al. analyzed the efficiency of three types of system incentives: rewards, punishments, and mixed rewards and punishments through group fitness [41]. Ma et al. constructed a symbiotic evolution between the behaviors of architecture enterprises and recycling enterprises without government incentives [42]. Wang et al. established an evolutionary game model for government and real estate enterprises. They analyzed how different incentive policies affect the decision-making process of real estate enterprises [43]. Zaman and Zaccour established a two-period game model between strategic consumers and the government, and the results determined the optimal level of subsidy for retirement [44].

3. Theoretical Basis and Assumptions

3.1. Analysis of the Primary Game Relationship

3.1.1. Management Committee. The management committee is mainly responsible for the deployment and formulation, and implementation of development plans and policies of the zones. The first is to improve the incentive mechanism; the second is to take the lead in technology transfer and promote the construction of an international science and technology innovation center; the third is to formulate policies and measures to provide guidance and services for these enterprises. The strategic choices of the management committee mainly include the implementation of reward and punishment measures and supervision tasks.

When the management committee chooses incentive regulation, high-tech and general enterprises that actively carry out independent innovation will be rewarded. In contrast, those who choose imitative innovation will be punished. Therefore, high-tech and general enterprises will conduct independent innovation activities to avoid punishment. When the management committee chooses nonincentive regulation, it relies more on power to manage enterprises. Although this method may urge passive innovation enterprises to innovate independently, it can also easily lead to "deception," that is, enterprises report the failure of independent innovation to avoid "the trouble"

3.1.2. High-Tech Enterprise. High-tech enterprises have many advantages, such as a higher technological level, more market share, and strong independent innovation capability. As the leaders of innovation and reforming, they can obtain larger innovation income. High-tech enterprises mainly carry out independent innovation in line with their development orientation and the policy orientation of the zone. Meanwhile, they are subject to the management committee's supervision, subsidies, and punishments. In addition, the independent innovation of high-tech enterprises will also bring tax revenue and social reputation to the management committee. Whether the management committee implements incentive measures, high-tech enterprises may still actively participate in independent innovation activities. However, since independent innovation has the characteristics of high cost, high risk, long cycle, and high risk of technology spillover, even if the management committee implements reward and punishment measures, high-tech enterprises may choose to imitate innovation over the technological upgrading process.

3.1.3. General Enterprises. General enterprises are relatively weak in technology and market share and tend to benefit from the innovation spillover of high-tech enterprises using cluster networks or purchasing patents. General enterprises mainly carry out independent innovation based on the market orientation and the management committee's policy guidance. They are also subject to the management committee's incentive regulation. In addition, the independent innovation of general enterprises will also bring tax revenue and social reputation to the management committee. Compared with high-tech enterprises, general enterprises are weak in technology and capital, but they will still try to actively participate in independent innovation activities due to maximized profits and long-term benefits. The management committee will subsidize general enterprises to conduct independent innovation activities when the management committee implements incentive measures. However, when general enterprises passively participate in independent innovation activities, they will also be punished.

3.2. Theoretical Assumptions and Model Construction. According to the relationship between the participants, the characteristics of regulation mode, and innovation methods, some assumptions are made as follows:

Hypothesis 1. The management committee (MC), high-tech enterprises (HE), and general enterprises (GE) all show bounded rationality.

Hypothesis 2. The strategic options of the management committee are (incentive regulation, nonincentive regulation), and the probability of incentive regulation is represented by $x \in [0, 1]$, then the probability of the latter is $1 - x$. The strategy options of high-tech enterprises are (independent innovation, imitative innovation), the probability of independent innovation is $y \in [0, 1]$, and that of imitative innovation is $1 - y$. Similarly, the strategy options of high-tech enterprises are (independent innovation, imitative innovation), the probability of independent innovation is $z \in [0,1]$, and that of imitative innovation is $1-z$.

Hypothesis 3. The revenue of high-tech enterprises choosing imitative innovation is R_2. The revenue that general enterprises choose imitative innovation is R_3. The increased cost of high-tech enterprises that choose independent innovation is C_2. The increased cost of general enterprises that choose independent innovation is C_3.

Hypothesis 4. When both high-tech and general enterprises choose imitative innovation and the management committee chooses nonincentive regulation, the corresponding tax revenue that the management committee obtains is G. The cost that the management committee chooses to supervise the enterprise is C_1.

Hypothesis 5. The benefits of enterprises choosing independent innovation are more significant than imitative innovation [45]. The increased revenue of high-tech enterprises that choose independent innovation is aR_2, and the increased revenue of general enterprises is bR_3. a, b represent the revenue growth rate, which is related to the enterprise's independent innovation cost and sales. In addition, enterprises that choose independent innovation in the same zone will produce technology spillovers for nonindependent innovation enterprises, and the technology spillover benefit of nonindependent innovation enterprises that will obtain is vbR_3. $v \in (0,1)$ is used to represent the technology spillover coefficient, which is subject to the degree of the protection of intellectual property rights and the absorptive capacity of the enterprises.

Hypothesis 6. If an enterprise chooses to innovate independently, it will bring political benefits (such as improved government image and reputation) and economic benefits (such as improved product quality and increased sales) to itself and the management committee. When the management committee chooses incentive regulation, sG is the increased revenue of high-tech enterprises that choose independent innovation; kG is the increased revenue of general enterprises that choose independent innovation. When the management committee chooses nonincentive regulation, mG is the increased revenue of general enterprises that choose independent innovation; nG is the increased revenue of general enterprises that choose independent innovation. s, m, k, n represent the rate of revenue in different situations, respectively.

Hypothesis 7. u is the patent royalty paid by the enterprises that choose imitative innovation to the enterprises that choose independent innovation.

Hypothesis 8. When the management committee chooses incentive regulation, pC_2 is the innovation subsidy value of high-tech enterprises that choose independent innovation; qC_3 is the innovation subsidy value of general enterprises that choose independent innovation. p, q are the innovation subsidy rate. If high-tech enterprises choose imitative innovation, they will be punished by the management committee with a value of fR_2. If general enterprises choose imitative innovation, they will be punished with a value of gR_3. f, g are the penalty rate.

The payoff matrix of participants is shown in Tables 1 and 2.

4. Evolutionary Game Path Analysis

4.1. Construction of Revenue Expectation Function. Tables 1 and 2 show that the expected revenue of the "incentive regulation" issued by the management committee is U_{MC1}, the expected revenue of the "nonincentive regulation" is U_{MC0}, and the average expected revenue of different incentive is $\overline{U}_{MC}$:

$$\begin{aligned}
U_{MC1} &= yz\left(-C_1+G+sG+kG-pC_2-qC_3\right)+y(1-z)\left(-C_1+G+sG-pC_2+gR_3\right)\\
&\quad+(1-y)z\left(-C_1+G+kG-qC_3+fR_2\right)+(1-y)(1-z)\left(-C_1+G+fR_2+gR_3\right),\\
U_{MC0} &= yz(G+mG+nG)+y(1-z)(G+mG)+(1-y)z(G+nG)+(1-y)(1-z)G,\\
\overline{U}_{MC} &= xU_{MC1}+(1-x)U_{MC0}.
\end{aligned} \tag{1}$$

The expected revenue of high-tech enterprises choosing "independent innovation" is U_{HE1}, the expected revenue of choosing "imitative innovation" is U_{HE0}, and the average expected revenue of different innovation is $\overline{U}_{HE}$:

$$\begin{aligned}
U_{HE1} &= xz\left(-C_2+R_2+aR_2+pC_2\right)+x(1-z)\left(-C_2+R_2+aR_2+pC_2-vaR_2+u\right)+(1-x)z\left(-C_2+R_2+aR_2\right)\\
&\quad+(1-x)(1-z)\left(-C_2+R_2+aR_2-vaR_2+u\right),\\
U_{HE0} &= xz\left(R_2-fR_2+vbR_3-u\right)+x(1-z)\left(R_2-fR_2\right)+(1-x)z\left(R_2+vbR_3-u\right)+(1-x)(1-z)R_2,\\
\overline{U}_{HE} &= yU_{HE1}+(1-y)U_{HE0}.
\end{aligned} \tag{2}$$

Table 1: Tripartite game payoff matrix when the management committee chooses "incentive regulation."

Participants		General enterprises	
		Independent innovation (z)	Imitative innovation ($1-z$)
High-tech enterprises	Independent innovation (y)	$-C_1+G+sG+kG-pC_2-qC_3$, $-C_2+R_2+aR_2+pC_2$, $-C_3+R_3+bR_3+qC_3$	$-C_1+G+sG-pC_2+gR_3$, $-C_2+R_2+aR_2+pC_2-vaR_2+u$, $R_3-gR_3+vaR_2-u$
	Imitative innovation ($1-y$)	$-C_1+G+kG-qC_3+fR_2$, $R_2-fR_2+vbR_3-u$, $-C_3+R_3+bR_3+qC_3-vbR_3+u$	$-C_1+G+fR_2+gR_3$, R_2-fR_2, R_3-gR_3

Table 2: Tripartite game payoff matrix when the management committee chooses "nonincentive regulation."

Participants		General enterprises	
		Independent innovation (z)	Imitative innovation ($1-z$)
High-tech enterprises	Independent innovation (y)	$G+mG+nG$, $-C_2+R_2+aR_2$, $-C_3+R_3+bR_3$	$G+mG$, $-C_2+R_2+aR_2-vaR_2+u$, R_3+vaR_2-u
	Imitative innovation ($1-y$)	$G+nG$, R_2+vbR_3-u, $-C_3+R_3+bR_3-vbR_3+u$	G, R_2, R_3

The expected revenue of general enterprises choosing "independent innovation" is U_{GE1}, the expected revenue of choosing "imitative innovation" is U_{GE0}, and the average expected revenue of different innovation is $\overline{U}_{GE}$:

$$\begin{aligned}U_{GE1} &= xy\left(-C_3+R_3+bR_3+qC_3\right)+x(1-y)\left(-C_3+R_3+bR_3+qC_3-vbR_3+u\right)+(1-x)y\left(-C_3+R_3+bR_3\right)\\&\quad+(1-x)(1-y)\left(-C_3+R_3+bR_3-vbR_3+u\right),\\U_{GE0} &= xy\left(R_3-gR_3+vaR_2-u\right)+x(1-y)\left(R_3-gR_3\right)+(1-x)y\left(R_3+vaR_2-u\right)+(1-x)(1-y)R_3,\\\overline{U}_{GE} &= zU_{GE1}+(1-z)U_{GE0}.\end{aligned} \tag{3}$$

4.2. Analysis of Evolutionary Stability Strategy Based on Replicator Dynamics Equations. According to (1), (2), and (3), the replicator dynamics equations for the management committee to select incentive regulation and high-tech and general enterprises to select independent innovation can be obtained, which are represented by $F(x)$, $F(y)$, and $F(z)$, respectively:

$$\begin{aligned}F(x) &= \frac{\mathrm{d}x}{\mathrm{d}t}\\&= x\left(U_{MC1}-\overline{U}_{MC}\right)\\&= x(1-x)\left[-C_1+ysG+zkG-ypC_2-zqC_3+(1-y)fR_2+(1-z)gR_3-ymG-znG\right],\end{aligned} \tag{4}$$

$$\begin{aligned}F(y) &= \frac{\mathrm{d}y}{\mathrm{d}t}\\&= y\left(U_{HE1}-\overline{U}_{HE}\right)\\&= y(1-y)\left[-C_2+R_2+aR_2+xpC_2-(1-z)vaR_2+(1-z)u-R_2+xfR_2-zvbR_3+zu\right]\\&= y(1-y)\left[-C_2+aR_2+xpC_2-(1-z)vaR_2+u+xfR_2-zvbR_3\right].\end{aligned} \tag{5}$$

$$\begin{aligned} F(z) &= \frac{\mathrm{d}z}{\mathrm{d}t} \\ &= z\left(U_{GE1} - \overline{U}_{GE}\right) \\ &= z(1-z)\left[-C_3 + R_3 + bR_3 + xqC_3 - (1-y)vbR_3 + (1-y)u - R_3 + xgR_3 - yvaR_2 + yu\right] \\ &= z(1-z)\left[-C_3 + bR_3 + xqC_3 - (1-y)vbR_3 + u + xgR_3 - yvaR_2\right]. \end{aligned} \tag{6}$$

According to the views of Ritzberger and Weibull [46], the replicator dynamics, and (4), (5), (6) are all 0, that is $F(x) = 0$, $F(y) = 0$, $F(z) = 0$, and the local equilibrium points can be obtained by solving, respectively: $E_1(0,0,0)$, $E_2(0,0,1)$, $E_3(0,1,0)$, $E_4(0,1,1)$, $E_5(1,0,0)$, $E_6(1,0,1)$, $E_7(1,1,0)$, $E_8(1,1,1)$. Whether the equilibrium point is stable can be judged by the Lyapunov discriminant method, that is, when the eigenvalues of the Jacobian matrix corresponding to the equilibrium point are all less than 0, the equilibrium point is stable [47].

4.3. Stability Analysis of Equilibrium. According to the method proposed by Friedman [48], the evolutionary stability strategy of the replicator dynamics equations composed of, and (4), (5), (6) can be obtained by the local stability analysis of the Jacobian matrix. The Jacobian matrix of the system is as follows:

$$J = \begin{bmatrix} (1-2x)(-C_1 + ysG + zkG - ypC_2 - zqC_3 + (1-y)fR_2 + (1-z)gR_3 - ymG - znG) & x(1-x)[sG - pC_2 - fR_2 - mG] & x(1-x)[kG - qC_3 - gR_3 - nG] \\ y(1-y)[pC_2 + fR_2] & (1-2y)[-C_2 + aR_2 + xpC_2 + u - (1-z)vaR_2 + xfR_2 - zvbR_3] & y(1-y)[vaR_2 - vbR_3] \\ z(1-z)[qC_3 + gR_3] & z(1-z)[vbR_3 - vaR_2] & (1-2z)[-C_3 + bR_3 + xqC_3 + u - (1-y)vbR_3 + xgR_3 - yvaR_2] \end{bmatrix}. \tag{7}$$

First, take the equilibrium point $E_1(0,0,0)$ as an example; after substituting the Jacobian matrix, we get

$$J = \begin{bmatrix} -C_1 + fR_2 + gR_3 & 0 & 0 \\ 0 & -C_2 + aR_2 - vaR_2 + u & 0 \\ 0 & 0 & -C_3 + bR_3 - vbR_3 + u \end{bmatrix}. \tag{8}$$

The eigenvalues of the equilibrium point $E_1(0,0,0)$ are $\lambda_1 = -C_1 + fR_2 + gR_3$, $\lambda_2 = -C_2 + aR_2 - \beta aR_2 + u$, and $\lambda_3 = -C_3 + bR_3 - \beta bR_3 + u$, respectively. In the same way, the eigenvalues corresponding to the other seven equilibrium points can be obtained, as shown in Table 3.

To facilitate the discussion of equilibrium point, let

$$\begin{aligned} A &= -C_1 + fR_2 + gR_3, \\ B &= -C_1 + kG - qC_3 + fR_2 - nG, \\ C &= -C_1 + sG - pC_2 + gR_3 - mG, \\ D &= -C_1 + sG + kG - pC_2 - qC_3 - mG - nG, \\ E &= -C_2 + aR_2 - vaR_2 + u, \\ F &= -C_2 + aR_2 - vbR_3 + u, \\ G &= -C_2 + aR_2 + pC_2 - vaR_2 + u + fR_2, \\ H &= -C_2 + aR_2 + pC_2 - vaR_2 + u + fR_2, \\ I &= -C_3 + bR_3 - vbR_3 + u, \\ J &= -C_3 + bR_3 - vaR_2 + u, \end{aligned}$$

$$\begin{aligned} K &= -C_3 + bR_3 + qC_3 + u - vbR_3 + gR_3, \\ L &= -C_3 + bR_3 + qC_3 + u + gR_3 - vaR_2. \end{aligned} \tag{9}$$

Based on the actual situation, this paper assumes that when the management committee chooses nonincentive regulation and the general enterprise chooses independent innovation, the revenue of high-tech enterprises that choose independent innovation is greater than that of imitative innovation, that is, $F > 0$. In addition, when $F > 0$, there is $H > 0$, which shows that the equilibrium points $E_2(0,0,1)$ and $E_6(1,0,1)$ are unstable points. This study is mainly divided into the following six scenarios for discussion:

Scenario 1: When $C_1 > fR_2 + gR_3$, $C_2 > aR_2 + pC_2 - vaR_2 + u + fR_2$, and $C_3 > bR_3 + qC_3 + u + gR_3 - vaR_2$, the system has only one stable equilibrium point $E_1(0,0,0)$, and its corresponding evolutionary stability strategy is (nonincentive regulation, imitative innovation, imitative innovation). Under this circumstance, enterprises are more inclined to choose imitative innovation, and independent innovation activities cannot

Table 3: Eigenvalues corresponding to the equilibrium point.

Equilibrium point	Eigenvalues λ_1	Eigenvalues λ_2	Eigenvalues λ_3
$E_1\,(0,0,0)$	$-C_1+fR_2+gR_3$	$-C_2+aR_2-vaR_2+u$	$-C_3+bR_3-vbR_3+u$
$E_2\,(0,0,1)$	$-C_1+kG-qC_3+fR_2-nG$	$-C_2+aR_2-vbR_3+u$	$-[-C_3+bR_3-vbR_3+u]$
$E_3\,(0,1,0)$	$-C_1+sG-pC_2+gR_3-mG$	$-[-C_2+aR_2-vbR_3+u]$	$-C_3+bR_3-vaR_2+u$
$E_4\,(0,1,1)$	$-C_1+sG+kG-pC_2-qC_3-mG-nG$	$-[-C_2+aR_2-vbR_3+u]$	$-[-C_3+bR_3-vaR_2+u]$
$E_5\,(1,0,0)$	$-[-C_1+fR_2+gR_3]$	$-C_2+aR_2+pC_2-vaR_2+u+fR_2$	$-C_3+bR_3+qC_3+u-vbR_3+gR_3$
$E_6\,(1,0,1)$	$-[-C_1+kG-qC_3+fR_2-nG]$	$-C_2+aR_2+pC_2-vaR_2+u+fR_2$	$-[-C_3+bR_3+qC_3+u-vbR_3+gR_3]$
$E_7\,(1,1,0)$	$-[-C_1+sG-pC_2+gR_3-mG]$	$-[-C_2+aR_2+pC_2+u-vaR_2+fR_2]$	$-C_3+bR_3+qC_3+u+gR_3-vaR_2$
$E_8\,(1,1,1)$	$-[-C_1+sG+kG-pC_2-qC_3-mG-nG]$	$-[-C_2+aR_2+pC_2+u-vbR_3+fR_2]$	$-[-C_3+bR_3+qC_3+u+gR_3-vaR_2]$

be realized, which is a situation that should be avoided in the zone.

Scenario 2: When $C_1>\max\{sG-pC_2+gR_3-mG, sG+kG-pC_2-qC_3-mG-nG\}$, $aR_2+pC_2-vbR_3+u+fR_2<C_2<aR_2-vaR_2+u$, and $C_3>bR_3+qC_3+u+gR_3-vaR_2$, the system has only one stable equilibrium point $E_3\,(0,1,0)$, and its corresponding evolutionary stability strategy is (nonincentive regulation, independent innovation, imitative innovation). Under this condition, high-tech enterprises are required to have a strong willingness for independent innovation.

Scenario 3: When $C_1>sG+kG-pR_2-qR_3-mG-nG$, $C_2<aR_2-vaR_2+u$, and $C_3<bR_3+u-vaR_2$, the system has only one stable equilibrium point $E_4\,(0,1,1)$, and its corresponding evolutionary stability strategy is (nonincentive regulation, independent innovation, independent innovation). The excellent independent innovation condition has been formed and the independent innovation of enterprises has reached a high level of spontaneity in the zone. High-tech and general enterprises are actively engaged in independent innovation.

Scenario 4: When $sG+kG-pC_2-qC_3-mG-nG<C_1<fR_2+gR_3$, $C_2>\max\{aR_2+pC_2-vaR_2+u+fR_2, aR_2+pC_2-vbR_3+u+fR_2\}$, and $C_3>\max\{bR_3+qC_3+u+gR_3-vaR_2, bR_3+qC_3+u+gR_3-vbR_3\}$, the system has only one stable equilibrium point $E_5\,(1,0,0)$, and its corresponding evolutionary stability strategy is (incentive regulation, imitative innovation, imitative innovation). Under this circumstance, the management committee's incentive regulation still cannot improve the independent innovation willingness of these enterprises, and the incentive regulation performance of the management committee is deficient. For high-tech and general enterprises, even if the management committee regulates them, the choice of imitative innovation can still bring more revenue, and imitative innovation is still the optimal strategy. This situation should be avoided in the zone.

Scenario 5: When $C_1<\min\{sG-pC_2+gR_3-mG, fR_2+gR_3\}$, $C_2<aR_2-vaR_2+u$, and $bR_3+qC_3+u+gR_3-vaR_2<C_3<bR_3-vbR_3+u$, the system has only one stable equilibrium point $E_5\,(1,0,0)$, and its corresponding evolutionary stability strategy is (incentive regulation, independent innovation, imitative innovation). Under this circumstance, the management committee's incentive regulation can reduce the independent innovation cost of high-tech enterprises, which makes high-tech enterprises more willing to take risks and carry out independent innovation. However, due to the high cost of independent innovation and the problems of market and product competition with high-tech enterprises, imitative innovation is a more promising strategy for general enterprises.

Scenario 6: When $C_1<sG-pC_2+gR_3-mG$, $C_2<aR_2-vaR_2+u$, and $C_3<\min\{bR_3+u-vaR_2, bR_3+u-vbR_3\}$, the system has only one stable equilibrium point $E_5\,(1,0,0)$, and its corresponding evolutionary stability strategy is (incentive regulation, independent innovation, independent innovation). Therefore, both high-tech and general enterprises choose independent innovation, and the management committee has the best incentive regulation performance in this case. It is the ideal state under the management committee's incentive regulation.

5. Numerical Simulation Analysis

MATLAB R2021a was used for the model simulation. We use numerical simulation to analyze the relevant factors that may impact different players' strategic choices. Suppose the parameter value are $C_1=2$, $C_2=5$, $C_3=7$, $R_2=14$, $R_3=12$, $G=7$, $f=0.3$, $g=0.3$, $a=0.8$, $b=0.6$, $v=0.15$, $s=0.8$, $k=0.8$, $m=0.5$, $n=0.5$, $u=3$, $p=0.15$, $q=0.15$. The initial willingness of the management committee, high-tech, and general enterprises are $x=0.5$, $y=0.5$, $z=0.5$, respectively.

The initial willingness of each participant is set as $x=y=z=0.2$, $x=y=z=0.5$, $x=y=z=0.8$, and the simulation results are shown in Figure 1. The evolutionary equilibrium result is $E_8\,(1,1,1)$. The higher the willingness of independent innovation, the shorter the convergence time for the strategy to converge to 1. The convergence time for high-tech enterprises to actively participate in independent innovation is the shortest, followed by general enterprises and the management committee.

5.1. Analysis of the Influence of Initial Willingness on the Evolution of Incentive Regulation.

With the condition that other parameters are unchanged, Figure 2(a) shows the

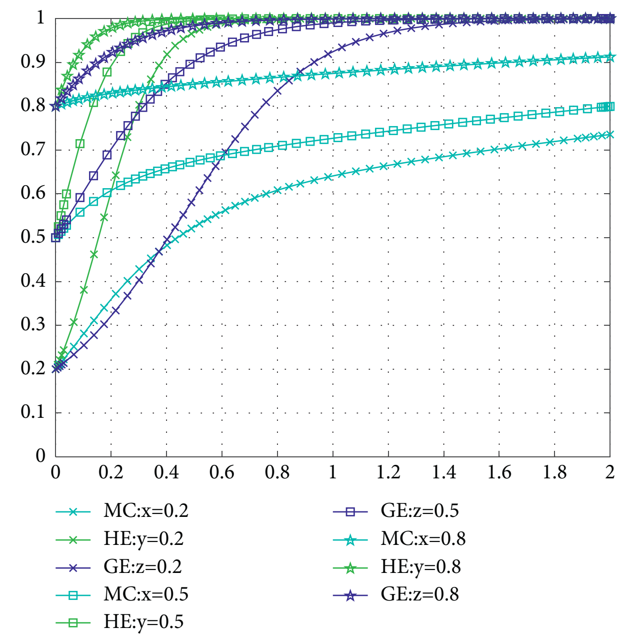


Figure 1: The evolution of the tripartite game under the initial value.

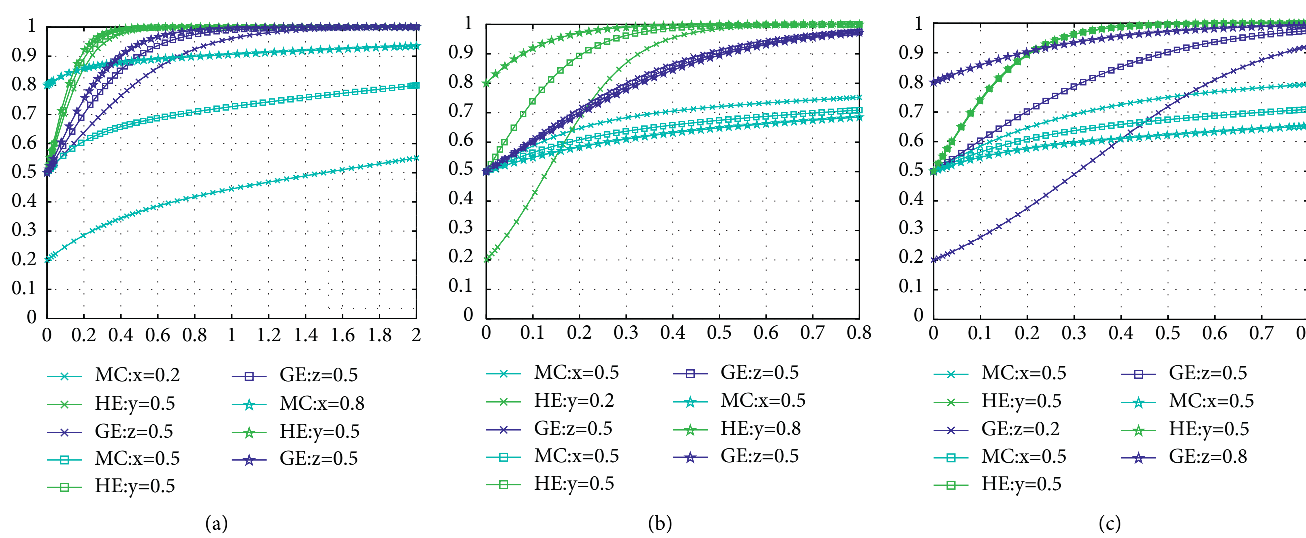


Figure 2: The evolutionary result of changes in participation willingness x (a), y (b), and z (c).

simulation results of the impact of changes in incentive regulation willingness x of the management committee on that of high-tech and general enterprises. Figure 2(b) shows the simulation results of the impact of changes in the initial willingness y of high-tech enterprises on that of the management committee and general enterprises. Figure 2(c) shows the simulation results of the impact of changes in the initial willingness z of general enterprises on that of the management committee and high-tech enterprises.

In this paper, the initial participation willingness of the management committee is set to $x = 0.2, 0.5, 0.8$, representing low willingness, medium willingness, and high willingness, respectively, and $y = z = 0.5$. Figure 2(a) shows that the higher the initial incentive regulation willingness of the management committee, the shorter the convergence time for high-tech and general enterprises to choose independent innovation. The management committee's incentive regulation willingness significantly impacts general enterprises more than high-tech enterprises.

Figure 2(b) is obtained by taking the value of $y = 0.2, 0.5, 0.8$ for the initial willingness of high-tech enterprises, and $x = z = 0.5$. According to the results, the higher the initial independent innovation willingness of high-tech enterprises, the slower the convergence speed of the management committee's choice of incentive regulation and the general enterprises' independent innovation choice. In addition, the management committee is more sensitive to changes in the initial willingness of high-tech enterprises.

Figure 2(c) is obtained by taking the value of $z = 0.2, 0.5, 0.8$ for the initial participation willingness of high-tech enterprises, and $x = y = 0.5$. In line with the results shown in the figure, the higher the initial independent innovation willingness of general enterprises, the longer the convergence time for the management committee to choose incentive regulation, and the shorter the convergence time for high-tech enterprises to choose independent innovation. The initial willingness of general enterprises has a significantly higher impact on the management committee than on high-tech enterprises.

The conclusion obtained in Figure 2 is that each participant is affected by the initial willingness of other participants. That is, (1) the management committee's initial incentive regulation willingness has a significantly higher positive influence on the independent innovation willingness of general enterprises than high-tech enterprises; (2) the initial independent innovation willingness of high-tech enterprises negatively affects the management committee's incentive regulation willingness and the general enterprises' independent innovation willingness. The impact on general enterprises is significant; (3) the general enterprises' independent innovation willingness negatively affects the management committee's incentive regulation willingness, but it positively affects the high-tech enterprises' independent innovation willingness; (4) the management committee's incentive regulation willingness is negatively affected by the increase in high-tech and general enterprises' initial independent innovation willingness.

5.2. Analysis of the Impact of Independent Innovation Costs on the Evolution of Independent Innovation

5.2.1. Analysis of the Impact of Cost Changes. The cost incurred by the management committee's incentive regulation is mainly manifested in two aspects: first, policy guidance and publicity, which will increase the enterprise's awareness of independent innovation, thereby forming the cultural condition of independent innovation in the zone; the second is financial subsidies and compensation. The management committee directly awards bonuses to enterprises through tax reductions and rebates, R&D subsidies, etc.

Figure 3 shows the simulation result of the impact of changes in the increased cost C_1 of the management committee's incentive regulation under the condition that other parameters remain unchanged. The increased cost C_1 is taken as $C_1 = 1, 2, 3, 4$, respectively. Figure 3 shows that the range of the critical value of C_1 is between 2 and 3. When the value of C_1 is less than the critical value, x converges to 1, and the final stable equilibrium point converges to $E_8(1, 1, 1)$. Currently, the increase of the value of C_1 slows down the convergence speed of x; when the value of C_1 is greater than the critical value, x converges to 0, and finally the stable equilibrium point converges to $E_4(0, 1, 1)$. In addition, the increase of the value of C_1 speeds up the convergence speed of x, and the convergence speed of y, z also speeds up. The simulation results show that the change in regulation cost C_1 is an essential factor that affects the strategic choice of the management committee.

Figure 4 shows the simulation of the impact of changes in the cost C_2 of independent innovation chosen by high-tech enterprises with the condition that other parameters remain unchanged. The cost C_2 of independent innovation of high-tech enterprises is set as $C_2 = 5, 6, 7, 8$ in Figure 4(a), and the cost C_2 of independent innovation is set to $C_2 = 11, 12, 13, 14$ in Figure 4(b). Figure 4(a) shows that the range of the critical value of C_2 is between 7 and 8. Figure 4(b) shows that the range of the upper limit of the value of C_2 is 13~14. Therefore, it can be considered that the upper limit value is the income of high-tech enterprises that choose independent innovation. When the value of C_2 is less than the critical value, y, z converges to 1, x also converges to 1, and the final stable equilibrium point is $E_8(1, 1, 1)$. As the value of C_2 increases, the convergence time that y, z approach 1 increase, and x converges to 0. When the value of cost C_2 is near the critical value, its change will have a more significant impact on the management committee. When the value of C_2 is less than the upper limit, y converges to 1. When the value of C_2 is greater than the upper limit, y is in an unstable state.

The simulation results show that when the value of C_2 is less than the benefits of independent innovation, high-tech enterprises will choose independent innovation. When the value of C_2 is greater than the benefits of independent innovation, high-tech enterprises will choose imitative innovation. When the value of C_2 is less than the critical value, the management committee will choose incentive regulation. When the value of C_2 is greater than the critical value, the management committee will choose non-incentive regulation. In other words, the greater the value of C_2, the more subsidies issued by the management committee, and the greater the economic pressure it will bear.

Figure 5 shows the simulation result of the impact of changes in the cost C_3 that general enterprises choose independent innovation with the condition that other parameters remain unchanged. The cost C_3 of general enterprises choosing independent innovation is selected as $C_3 = 8, 9, 10, 11$. Figure 5 shows that the range of the critical value of C_3 is between 9 and 10, and the change of the value C_3 has a significantly higher impact on the management committee than that of high-tech and general enterprises. When the value of C_3 is less than the critical value, x converges to 1, and the final evolutionary stable point is $E_8(1, 1, 1)$. When the value of C_3 is greater than the critical value, x converges to 0, and the final evolutionary stable point is $E_4(0, 1, 1)$.

In line with the simulation results in Figures 3-5, the independent innovation cost of high-tech and general enterprises are also important factors that affect the strategic choice of the management committee.

5.2.2. Analysis of the Impact of Technology Spillover Coefficient and Patent Royalty. Figure 6 shows the simulation result of the impact of changes in the technology spillover coefficient v with the condition that other parameters remain

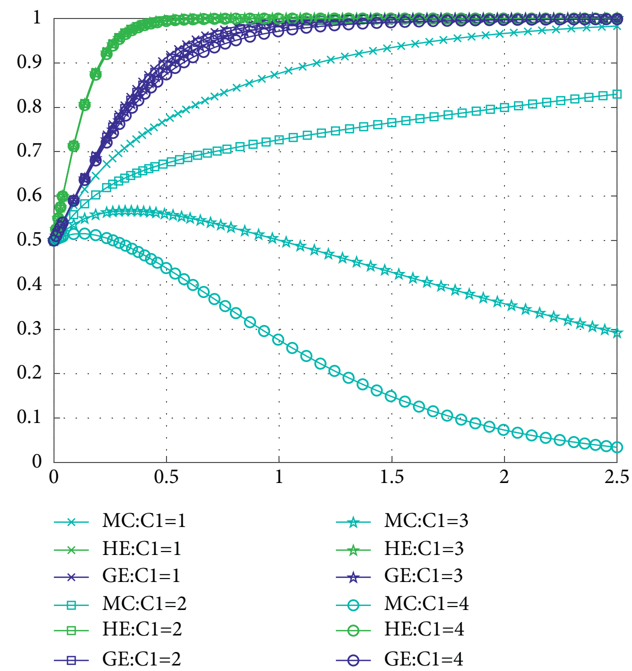


FIGURE 3: The evolutionary result of the change in incentive regulation cost C_1.

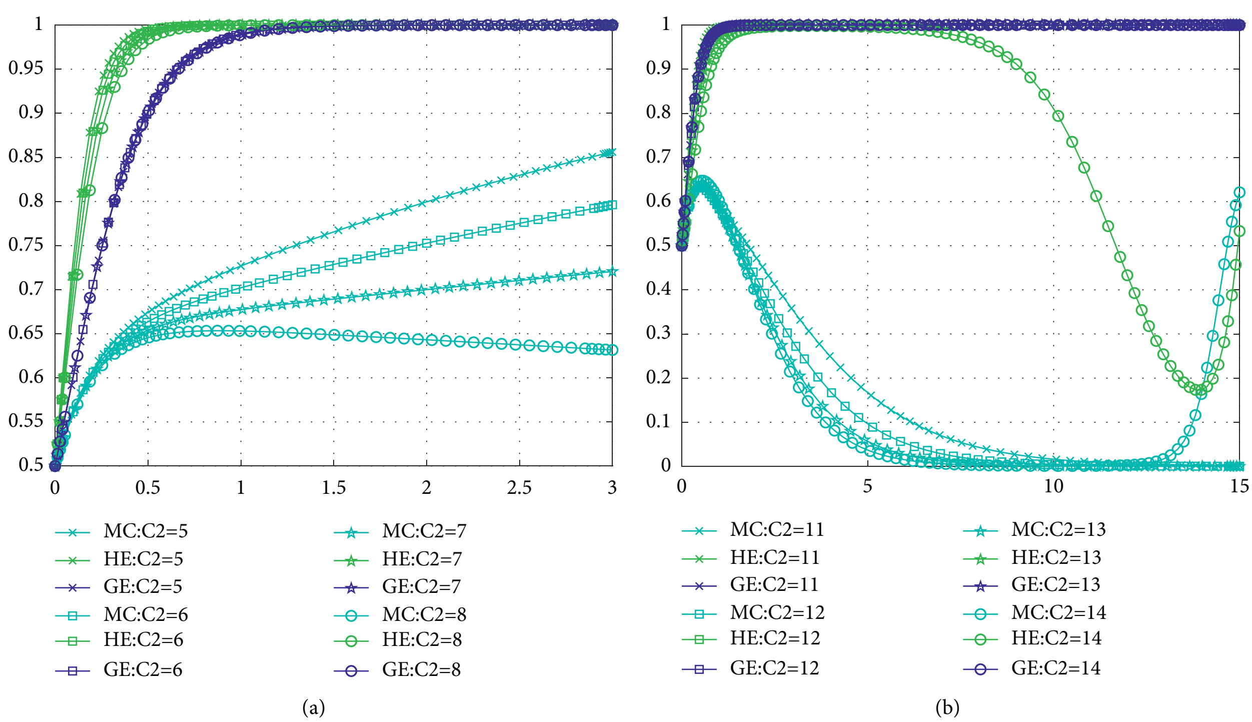


FIGURE 4: The evolutionary results of high-tech enterprises choosing independent innovation costs.

unchanged. The value of v is taken as $v = 0.1, 0.3, 0.4, 0.5$. Figure 6 shows that the range of the critical value of v is between 0.4 and 0.5, and the change of v has a significantly higher impact on the convergence speed of z than that of x and y. With the increase of the value of v, the convergence time that y and z approach 1 gradually increase, while the convergence time that x approaches 1 gradually decreases. The simulation results show that technology spillover cuts down the independent innovation willingness of high-tech and general enterprises.

Figure 7 shows the simulation result of the impact of changes in patent royalty u with the condition that other parameters remain unchanged. The value of the patent royalty u is set to $u = 2, 3, 4, 5$ and $u = 6, 7, 8, 9$, and

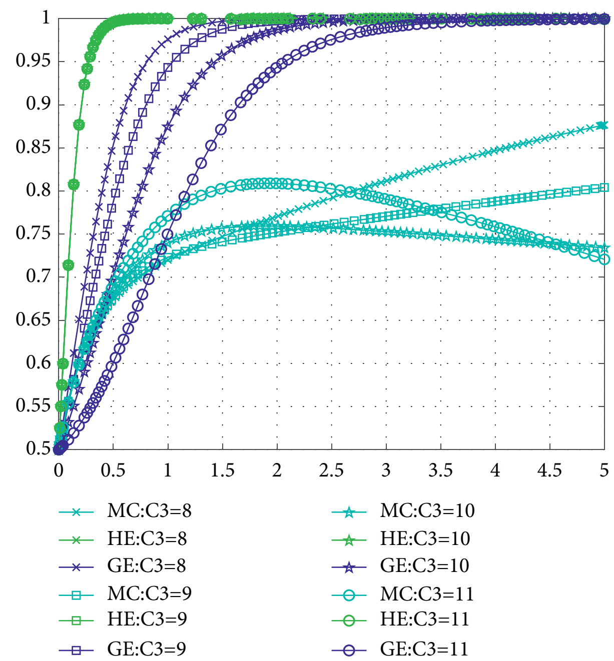


Figure 5: Evolutionary results of changes in independent innovation costs of general enterprises.

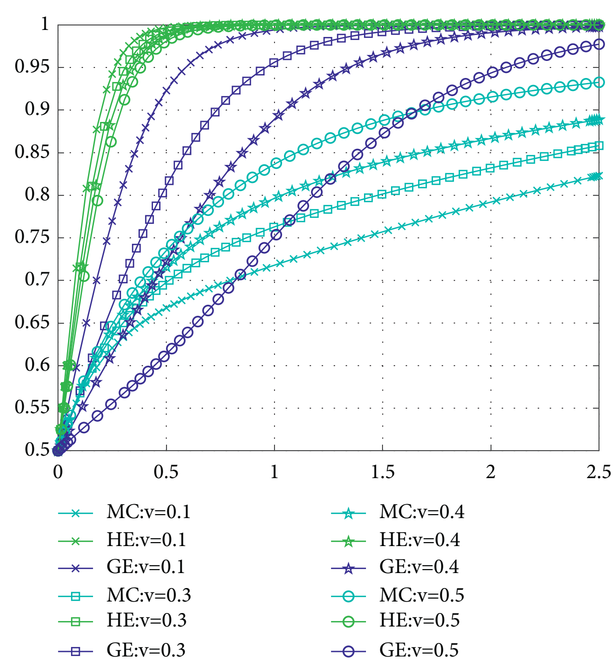


Figure 6: Evolution result of changes in technology spillover coefficient.

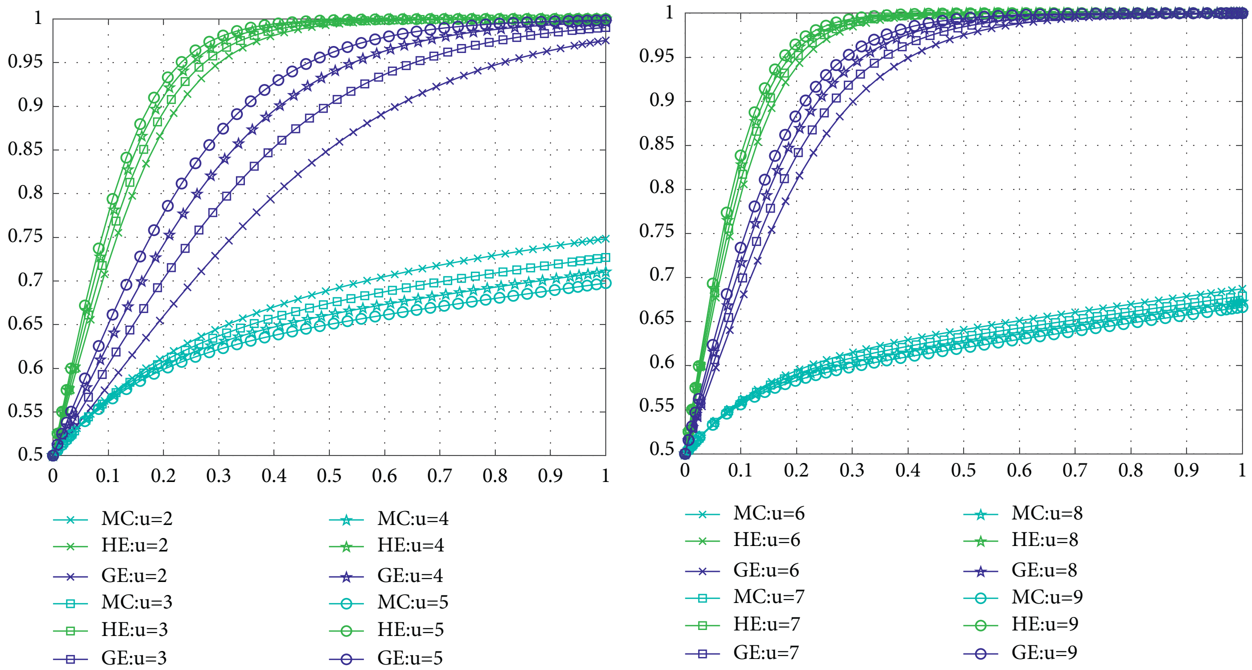
Figures 7(a) and 7(b) are obtained, respectively. Figure 7(a) shows that the range of the critical value of v is 4~5 for high-tech enterprises; Figure 7(b) shows that the range of the critical value of u is 6~7 for general enterprises. The critical value of patent royalty for high-tech and general enterprises is the cost of their independent innovation. When the value of u is less than the critical value, the convergence time that y, z approach 1 gradually decrease, while the convergence time that x approaches 1 gradually increases. However, when the value of u is greater than the critical value, the convergence time that x, y, z approach 1 do not decrease significantly. The simulation results show that the increase in patent royalty positively affects the choice of high-tech and general enterprises.

5.3. Analysis of the Impact of the Management Committee's Incentive on the Independent Innovation

5.3.1. Analysis of the Impact of Innovation Subsidy Rate. Figure 8 shows the simulation result of the impact of changes in the innovation subsidy rate p, q with the condition that other parameters remain unchanged. Figure 8(a) shows that the innovation subsidy rate p, q and the penalty rate f, g are taken as $f = g = 0$ and $p = q = 0.1, 0.15, 0.2$, respectively. The range of the critical value of p, q is between 0.15 and 0.2. When the value of p, q is less than the critical value, x, y, z all converge to 1, and the final evolutionary stable point is $E_8(1, 1, 1)$. When the value of p, q is greater than the critical value, x converges to 0, and y, z approach 1. The convergence time decreases, and the final evolutionary stable point is $E_4(0, 1, 1)$. The simulation results show that when the management committee implements the same incentive measures for high-tech and general enterprises, the critical value of the innovation subsidy rate p, q is between 0.15 and 0.2.

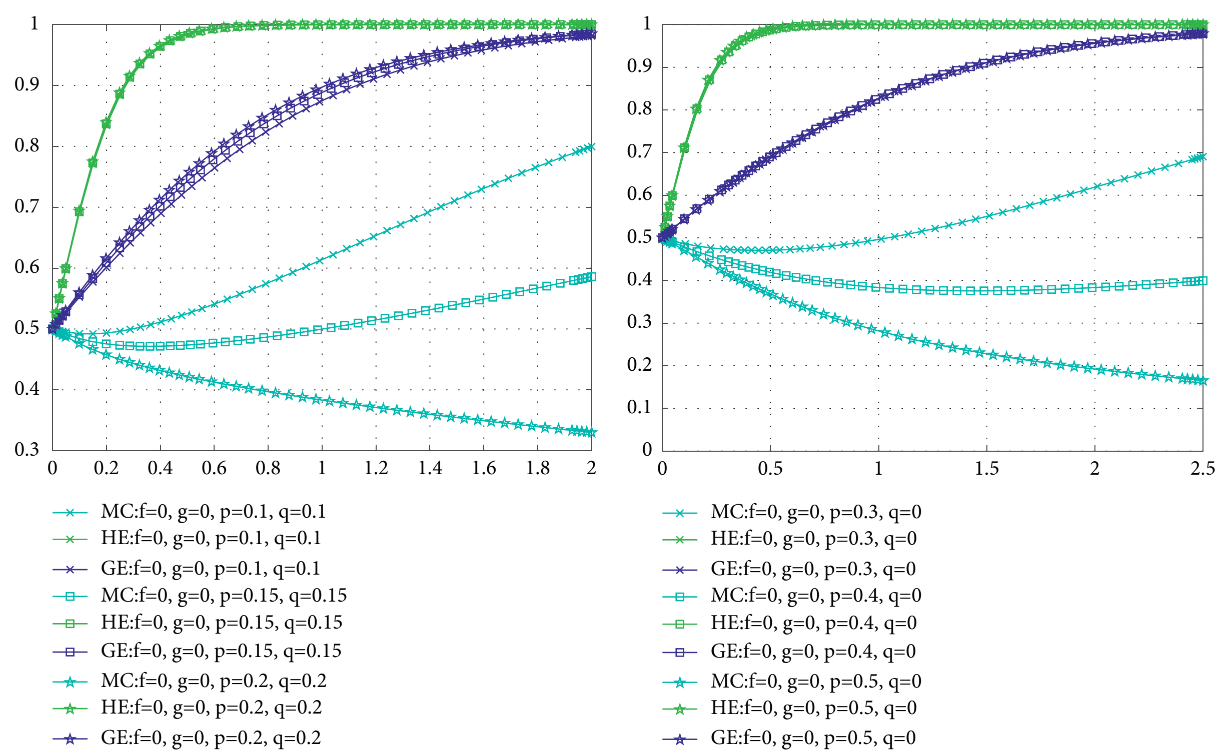
Figure 8(b) shows the simulation result only considers the impact of changes in innovation subsidies for high-tech enterprises with the condition that other parameters remain unchanged. We set the innovation subsidy rate p, q and the penalty rate f, g as $f = g = q = 0$ and $p = 0.3, 0.4, 0.5$, respectively. The range of the critical value of p is between 0.4 and 0.5. When the innovation subsidy rate p is less than the critical value, x, y, z converge to 1; when the innovation subsidy rate p is greater than the critical value, x converges to 0, and y, z approach 1. The convergence time of y is decreased, and that of z is increased. The simulation results show that when the management committee only implements incentive measures for high-tech enterprises, the critical value of the innovation subsidy rate p is between 0.4 and 0.5. The increase in the innovation subsidy rate of high-tech enterprises has a positive effect on their independent innovation activities but has a negative effect on the independent innovation activities of general enterprises.

Figure 8(c) shows the simulation result only considers the impact of changes in innovation subsidies for general enterprises with the condition that other parameters remain unchanged. We set the innovation subsidy rate p, q and the penalty rate f, g as $f = g = p = 0$ and $q = 0.2, 0.3, 0.4$, respectively. The range of the critical value of q is between 0.3 and 0.4. When the innovation subsidy rate q is less than the critical value, x, y, z converge to 1. When the innovation subsidy rate q is greater than the critical value, x converges to 0, y, z approach 1 and the convergence time of y, z decrease. The simulation results show that when the management committee only implements incentive measures for general enterprises, the critical value of the innovation subsidy rate q is between 0.3 and 0.4. The increase in the innovation



(a) (b)

Figure 7: Evolutionary results of changes in patent royalty.



(a) (b)

Figure 8: Continued.

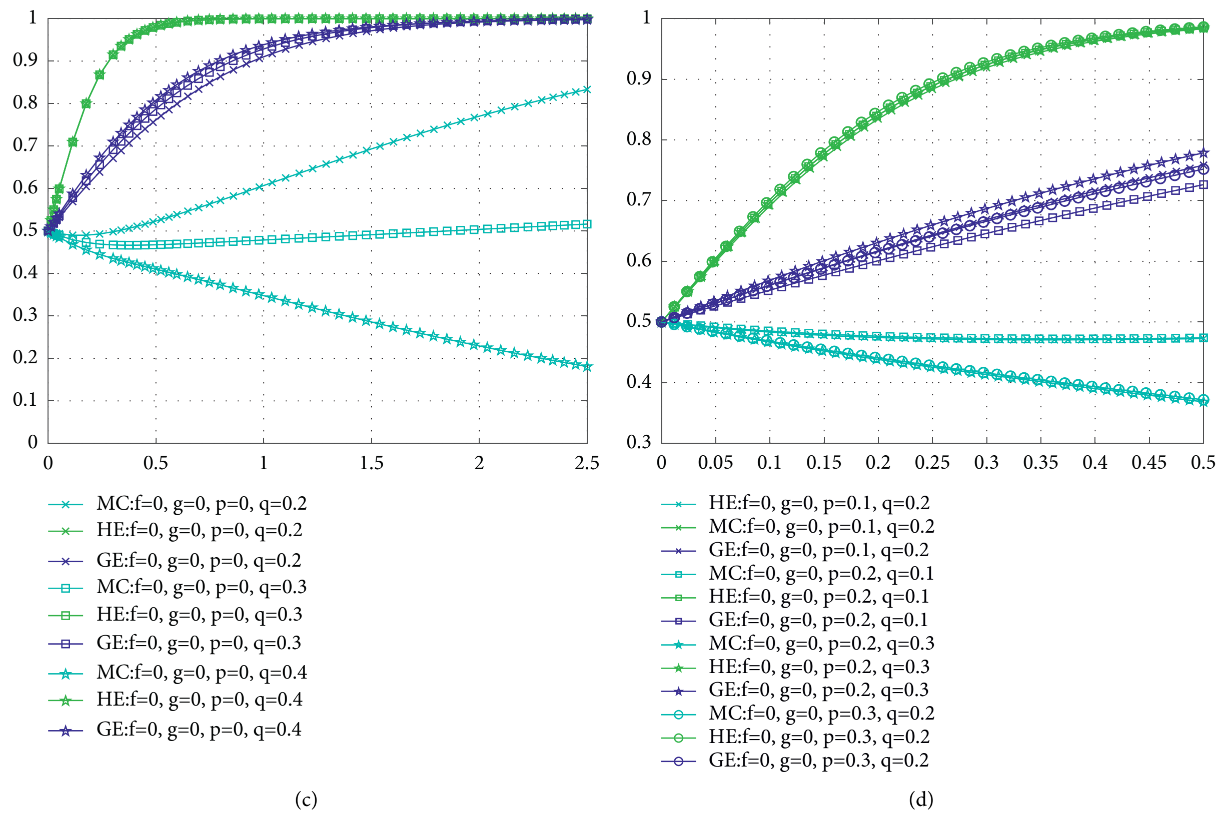


Figure 8: The evolution result of the innovation subsidy rate p, q change. (a) p, q are equal changes. (b) Only p changes. (c) Only q changes. (d) p, q are not equal changes.

subsidy rate of general enterprises positively effects on the independent innovation activities of high-tech and general enterprises.

Figure 8(d) shows the simulation result only considers the impact of unequal changes in the innovation subsidy rate with the condition that other parameters remain unchanged. We set the penalty rate f, g as $f = g = 0$ and the innovation subsidy rate p, q as $p = 0.1, q = 0.2$, $p = 0.2, q = 0.1$, $p = 0.2, q = 0.3$, $p = 0.3, q = 0.2$, respectively. Figure 8(d) shows that the convergence speed of high-tech and general enterprises to choose independent innovation is related to the innovation subsidy rate and related to the relative innovation subsidy rate. The higher the innovation subsidy rate, the shorter the convergence time when the probability of high-tech enterprises that choose independent innovation approaches 1. When the innovation subsidy rate of high-tech enterprises is higher than that of general enterprises, its convergence time is faster than when it is lower than that of general enterprises, and vice versa.

Figure 8 shows the effect that the management committee implements the innovation subsidy only on high-tech enterprises is better than that the management committee implements the innovation subsidy for both and higher subsidy for high-tech enterprises. Moreover, the effect that the management committee implements the innovation subsidy for both and higher subsidy for high-tech enterprises is better than that the management committee implements the same innovation subsidy for both. In contrast, the effect that the management committee implements the same innovation subsidy for both is better than that the management committee implements the innovation subsidy rate for both and higher subsidy for the general enterprises. Finally, the effect that the management committee implements the innovation subsidy rate for both and higher subsidy for the general enterprises is better than that the management committee only implements the innovation subsidy for the general enterprises.

5.3.2. Analysis of the Impact of Penalty Rate. Figure 9 shows the simulation result only considers the impact of changes in the penalty rate f, g with the condition that other parameters remain unchanged. We set the penalty rate f, g and the innovation subsidy rate p, q as $p = q = 0$ and $f = g = 0.1, 0.2, 0.3, 0.4$, respectively. It can be seen from Figure 9(a) that the range of the critical value of f, g is between 0.3 and 0.4. When the value of f, g are less than the critical value, as the penalty rate f, g increase, the probability that the management committee chooses incentive regulation and high-tech and general enterprises choose independent innovation will approach 1, and the convergence time will gradually decrease. When the penalty rate f, g are greater than the critical value, the evolution result of the management committee, high-tech and general enterprises is still close to 1, but the convergence time has not changed

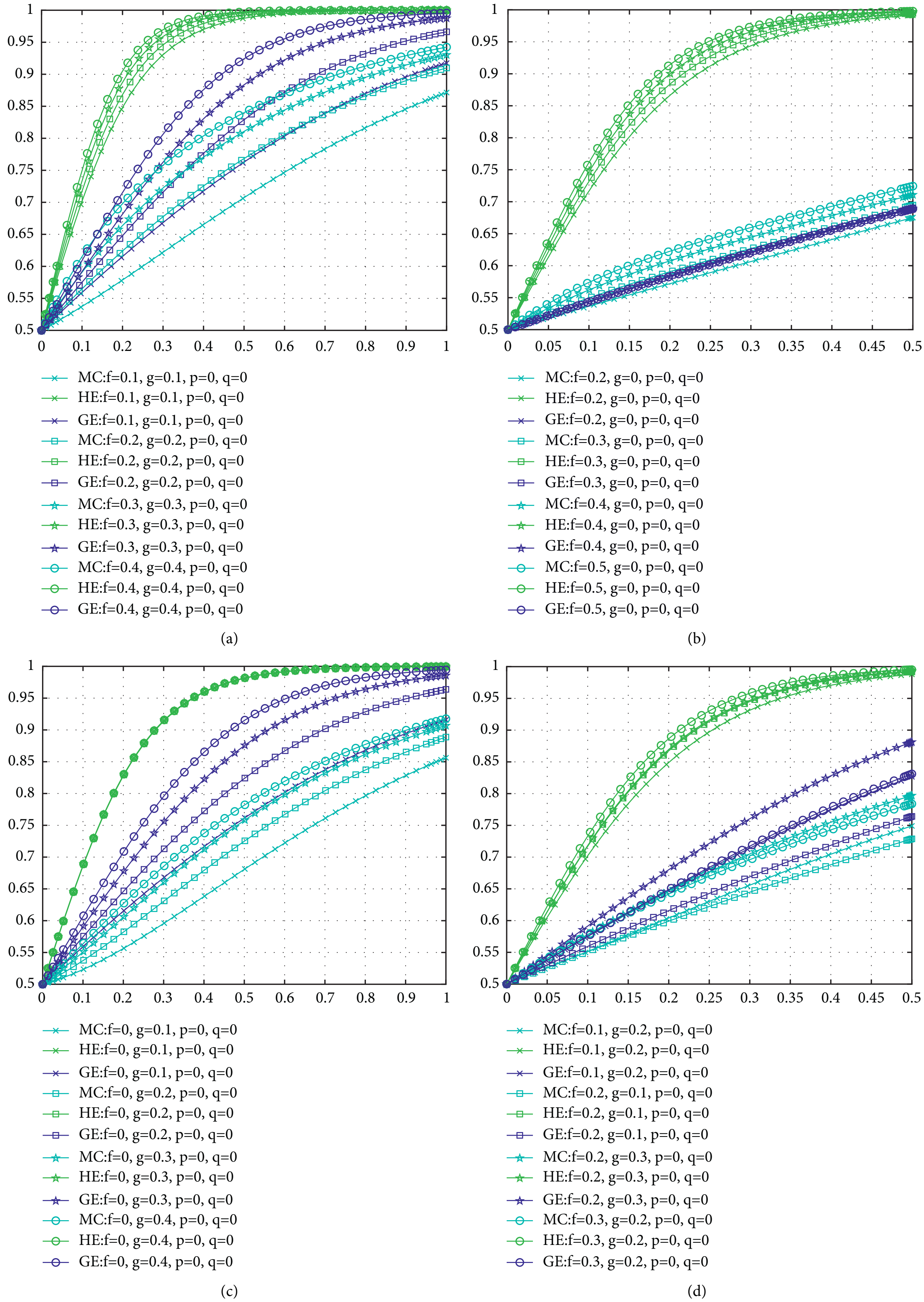


Figure 9: The evolution result of the penalty rate change. (a) f, g are equal changes. (b) Only f changes. (c) Only g changes. (d) f, g are not equal changes.

significantly. Currently, the increase in the value of f, g has no significant impact on the participants.

Figure 9(b) shows the simulation result only considers the impact of the change in the penalty rate f of the management committee on high-tech enterprises with the condition that other parameters remain unchanged. We set the penalty rate f, g and the innovation subsidy rate p, q as $p = q = g = 0$ and $f = 0.1, 0.2, 0.3, 0.4$, respectively. The range of the critical value of the penalty rate f is between 0.4 and 0.5. When the penalty rate f is less than the critical value, as the management committee increases the penalty rate for high-tech enterprises, the probability of choosing independent innovation gradually increases. In contrast, the probability that general enterprises choose independent innovation gradually decreases. When the punishment rate increases, the probability that high-tech enterprises choose independent innovation will approach a steady-state faster. When the penalty rate f is greater than the critical value, the convergence time that high-tech and general enterprises choose independent innovation do not significantly decrease.

Figure 9(c) shows the simulation result only considers the impact of the change in the penalty rate g of the management committee on general enterprises with the condition that other parameters remain unchanged. We set the penalty rate f, g and the innovation subsidy rate p, q as $p = q = f = 0$ and $g = 0.1, 0.2, 0.3, 0.4$, respectively. The range of the critical value of the penalty rate g is between 0.3 and 0.4. When the penalty rate g is less than the critical value, as the management committee increases the penalty rate for general enterprises, the probability that high-tech and general enterprises choose independent innovation increases. When the penalty rate g is greater than the critical value, the convergence time that high-tech and general enterprises choose independent innovation do not significantly decrease.

Figure 9(d) shows the simulation result only considers the impact of unequal changes in the penalty rate f, g with the condition that other parameters remain unchanged. We set the innovation subsidy rate p, q, as $p = q = 0$, and the penalty rate f, g as $f = 0.1, g = 0.2$, $f = 0.2, g = 0.1$, $f = 0.2, g = 0.3$, $f = 0.3, g = 0.2$. Meanwhile, the convergence speed that high-tech and general enterprises choose independent innovation is subject to the punishment rate of the management committee and the relative punishment rate. The higher the penalty rate issued by the management committee on high-tech enterprises, the shorter the convergence time that the probability that high-tech enterprises choose independent innovation. When the penalty rate for high-tech enterprises is higher than that of general enterprises, the convergence speed is faster than when implementing the lower rate of innovation subsidies for high-tech enterprises. This result also applies to general enterprises.

Figure 9 shows the effect that the management committee only implements the punishment on general enterprises is better than that the management committee implements the punishment on both and the higher penalty rate on the general enterprises. Moreover, the effect that the management committee implements the punishment on both and the higher penalty rate on the general enterprises is better than that the management committee implements the same penalty rate on both. Moreover, the effect that the management committee implements the same penalty rate on both is better than that the management committee implements the punishment on both and the higher penalty rate on the high-tech enterprises. Finally, the effect that the management committee implements the punishment on both and the higher penalty rate on the high-tech enterprises is better than that the management committee only implements the punishment on high-tech enterprises.

According to Figures 8-9, high-tech and general enterprises are more sensitive to the punishments issued by the management committee than the rewards. The management committee should attach importance to subsidies for high-tech enterprises and strengthen the regulation for general enterprises, which will be more conducive to incentive regulation performance.

6. Conclusions and Suggestions

Based on the bounded rationality of the game party, this paper uses the evolutionary game theory to establish the game model of independent innovation incentive regulation. It systematically analyzes the decision-making evolution process of the incentive regulation of the management committee and the selection of innovation types of high-tech and general enterprises.

(1) The initial willingness of the management committee, high-tech and general enterprises have different degrees of influence on each other, which is mainly reflected in three aspects. (1) The initial willingness of high-tech and general enterprises has a significant impact on the strategic selections of the management committee. The main reason is that the management committee is committed to promoting high-tech and general enterprises to actively participate in independent innovation activities in the construction of the zones. (2) High-tech and general enterprises have an asymmetrical influence on each other, and general enterprises are more sensitive to changes in the initial willingness of high-tech enterprises to participate in independent innovation. When the number of enterprises that carry out independent innovation activities increases, the general enterprise will actively carry out independent innovation activities to survive for a long time. (3) The incentive regulation effect of the management committee on the independent innovation of general enterprises is significantly higher than that of high-tech enterprises. The incentive regulation of the management committee can provide direct financial support for general enterprises, thereby reducing their independent innovation costs. However, high-tech enterprises can stimulate the willingness for independent innovation of general enterprises.

(2) These factors, such as the independent innovation cost, technology spillover coefficient, and patent

royalty, significantly affect the participant's strategic selection. The management committee is more sensitive to changes in the independent innovation costs of various entities, while general enterprises are more sensitive to changes in technology spillover coefficients and patent royalty. Therefore, the management committee should strengthen the protection of intellectual property rights to form a good market environment for independent innovation. Meanwhile, the management committee should devote itself to providing a high-quality policy environment for high-tech and general enterprises to save the cost of independent innovation of enterprises.

(3) The incentive regulation of the management committee is to improve the innovation performance of enterprises by increasing their willingness to innovate, and different types of enterprises have different effects. The reward and punishment measures implemented by the management committee will have a positive and significant impact on the independent innovation willingness of high-tech and general enterprises. However, compared with incentive measures, punishment measures have a more significant impact on the willingness of high-tech and general enterprises. Meanwhile, in the dynamic reward state, the higher the innovation subsidy provided by the management committee to high-tech and general enterprises, the better the incentive regulation performance of the management committee. In addition, high-tech enterprises are more sensitive to incentive measures than general enterprises. Under the coexistence of incentives and penalties, if the management committee provides higher incentives to high-tech enterprises and heavier penalties to general enterprises, it can produce better incentive regulation performance.

Based on the above conclusions, this paper draws the following policy implications: (1) Implement differentiated reward and punishment policies in the zone to improve the management committee's incentive regulation performance. Firstly, the management committee should be more objective and targeted when providing rewards and punishments. Secondly, it is necessary to shift policy resources to high-tech enterprises with higher innovation preferences and better subsidy effects in a timely and appropriate manner to make up for the "gap" of innovation input by high-tech enterprises. Finally, the management committee needs to strengthen the regulation of general enterprises to enhance the effectiveness of incentive regulation. (2) The management committee needs to continue to strengthen its support for enterprises. Considering the significant impact of independent innovation costs on enterprises' independent innovation willingness, the management committee should devote itself to implementing policies. The policies should help reduce enterprises' initial independent innovation costs (for example, providing tax reduction policies, attractive policies for introducing high-tech talents, and policy funds for enterprises' independent innovation) to improve the management committee's incentive regulation performance. (3) Create a favorable atmosphere for independent innovation in the demonstration zone. The management committee should increase the protection of intellectual property rights and reduce technology spillovers between enterprises. In addition, the management committee should use its resource advantages to build international cooperation and exchange platform for enterprises and form an information sharing and exchange mechanism. Enterprises should speed up the introduction, digestion, and absorption of international scientific and technological achievements, to increase the speed of independent innovation.

Although the results in this paper have policy significance for the management committee to formulate and improve the independent innovation incentive mechanism, there are also some limitations. First of all, the results show that the incentive measures mainly based on innovation subsidies can promote the independent innovation of enterprises. However, in reality, there are other subsidy methods, such as technological innovation subsidies [49], product innovation subsidies [50], tax incentives [51], and loan subsidies [52]. Different subsidy measures lead to different incentive effects, while this paper does not conduct a comparative study. Therefore, we will study the impact of various incentive policies on enterprises' strategic choices in future research. Second, the parameters in this study are hypothetical, and the simulation graph can only reflect the general trend of strategy selections of each subject. Therefore, we will focus on collecting actual data for simulation to improve the rationalization level of the strategic choices of each player and then provide more accurate reference suggestions for the management committee. Therefore, this paper will collect actual data for simulation to improve the rationalization level of each player's strategy selection in future research and then provide more accurate reference suggestions for the management committee.

Data Availability

The data used to support the findings of this study have not been made available because raw data are hard to obtain. So, this study uses hypothetical data for simulation rather than real data.

Conflicts of Interest

The authors declare no conflicts of interest.

Authors' Contributions

P.D. and Y.W. conceptualized the study; P.D. was responsible for methodology; K.T. performed formal analysis; P.D. prepared the original draft; P.D. and K.T. reviewed and edited the manuscript; K.T. was involved in supervision; Y.W. and P.D. were involved in funding acquisition; all authors have read and agreed to the published version of the manuscript.

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Supplementary Materials

The supplementary file is mainly the numerical simulation code for each figure in Section 5. The code for each figure is well commented and run through MATLAB R2021a software. (*Supplementary Materials*)

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