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Protecting Innovation Sustainability: R&D Manipulation and Effective Regulation Based on a Two-Scenario Evolutionary Game Perspective

Wen Qi *, Yanyang Yan and Hongbing Yin

College of Finance & Statistics, Hunan University, Changsha 410000, China
* Correspondence: wennerq@hnu.edu.cn

Abstract: Enterprise innovation is the core content of national innovation and an important issue for sustainable development. Therefore, this paper focuses on the phenomenon of R&D manipulation in the declaration of high-tech enterprises, constructs a two-scenario two-party evolutionary game model in which central governments do or do not join in the supervision of local governments and the declaration enterprises and simulates and analyzes the direction of each key variable on the strategy selection of the game subject and degree of impact. The study finds that reducing tax rates is beneficial to avoid enterprise R&D manipulation, while innovation performance and regulatory costs drive local governments to reduce regulation. Further analysis shows that central government's participation in supervision reduces enterprise R&D manipulation and strengthens local government regulation. The research results could promote the standardization of enterprise innovation behavior and mitigate local government slack, thereby fostering sustainable innovation and development.

Keywords: R&D manipulation; local government regulation; central government supervision; evolutionary game

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1. Introduction

Sustainable innovation can realize the coordinated development of the economy, society, and environment, and provide the foundation and guarantee for long-term high-quality development [1–3]. The Report of the 20th National Congress of the Communist Party of China emphasizes the crucial role of innovation as the first driving force of development and the strategic pillar for building a modern economic system. At present, scholars have made remarkable progress in the research of environmental innovation, frugal innovation, ecological innovation, and social innovation [4–7], which would play an important role in the promotion of innovation and sustainable development. In addition, the role of enterprises as important innovation subjects in sustainable development cannot be ignored. Enterprises can not only achieve their own sustainable development through technology and business model innovation, but also have a positive impact on the entire society and the environment [8,9].

Enterprise R&D activities are the source of enterprise innovation and an important engine for enterprise development. However, enterprises' innovation behavior is often characterized by large investment amounts and uncertain output returns. Therefore, governments generally adopt innovative financial subsidy policies to encourage and stimulate enterprises to increase R&D activities. Tax cuts and patent subsidies for high-tech enterprises are the most typical R&D subsidy policies. Only enterprises whose R&D intensity and number of patent applications (authorizations) reach the threshold can be identified as high-tech enterprises and then enjoy tax relief and other benefits from the governments. The "subsidy threshold" can easily prompt enterprises to carry out R&D manipulations to meet the threshold requirements, resulting in a tendency to make self-interested decisions and arbitrage policy dividends [10]. In the short term, by R&D manipulation, companies

may obtain false technological breakthroughs or innovations, allowing them to gain an advantage in market competition, attract the attention of investors or partners, and establish a competitive brand image [11–13]. However, in the long term, excessive focus on manipulating R&D and ignoring actual scientific research and technological innovation may lead to low R&D efficiency, which not only violates relevant laws and regulations but also affects the long-term development of enterprises [14–16]. Therefore, strict supervision of corporate R&D manipulation is the key to the effective implementation of innovation policies. In fact, in the promotion tournament mode, due to the consideration of local innovation performance, local governments are very likely to be slack in supervising the behavior of enterprise R&D manipulation. As a result, the phenomenon of the so-called "Win–Win Dilemma" has emerged [17]. Addressing this issue requires developing effective monitoring mechanisms to prevent R&D manipulation and promote genuine innovation. This can be achieved by improving the transparency and accountability of the recognition system, implementing effective monitoring and inspection mechanisms, and fostering a culture of innovation that values quality and impact over quantity.

In 2018, the State Intellectual Property Office (SIPO) issued a notice regarding suspected irregular patent applications in Guangdong Province. In 2019, Guangdong Province and the State Administration of Taxation (SAT) jointly issued notices revoking the high and new technology enterprise qualifications of 22 enterprises, and the qualifications of 32 enterprises, In 2021, the State Intellectual Property Office issued another notice to regulate patent application behavior further. Figures 1 and 2, respectively, show the top five provinces (municipalities) that have disqualified high-tech enterprises in recent years and the number of disqualified high-tech enterprises in the past years. It is obvious that central governments have played an important role in dealing with the inaction of local governments in the face of corporate R&D manipulation chaos, especially in implementing tightened policies in recent years. On the one hand, central governments have urged and interviewed local governments to order rectification. On the other hand, central governments cancel the qualification of some falsely rated high-tech enterprises. There are some questions raised worth thinking about. What role do the local governments play in the high-tech qualification certification of enterprises? What impact do they have on the R&D manipulation of enterprises? Furthermore, in the context of the "dual goals" of the central and local governments, what impact will the direct participation of central governments have on the regulatory decisions of local governments? Therefore, it is particularly necessary to study the evolutionary game between high-tech enterprises, local governments, and central governments, which will help promote innovation and development, enhance government supervision capabilities, optimize government roles and responsibilities, strengthen policy coordination, prevent and curb manipulation behavior, and achieve high-quality economic and social development.

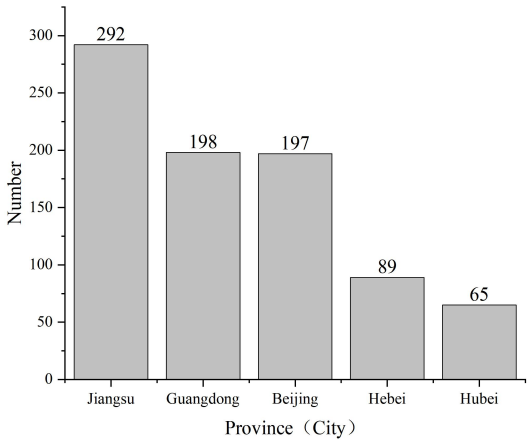

Figure 1. The top five provinces (cities) with the most disqualified high-tech enterprises.

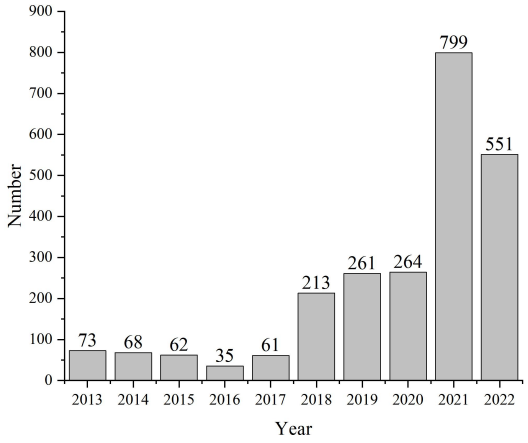

Figure 2. The Number of Disqualifications of High-tech Enterprises Over the Years.

Scholars have applied research on evolutionary games to many fields, and game subjects have gradually expanded to three or more, which enriches the game scenarios and makes the research more in line with reality. Based on this, this paper constructs a two-scenario evolutionary game model in which central governments join in the supervision of local governments and the declaration enterprises and quantitatively analyzes the impact of relevant parameter changes on the direction and degree of the main strategy through simulation, providing a reference for the government to improve the effective supervision of corporate R&D manipulation behavior. The following are the research contributions of this paper. (1) Based on the research method, the game of the participants is a random, shared learning and repeated game process, and the adjustment process of individual strategies can be modeled by using the replication dynamics mechanism. The game behavior of multi-party subjects in the determined environment provides a reference for ideas [18–22]. (2) Based on the research perspective, previous research on R&D manipulation has mostly focused on the enterprise level [23–26], and detailed analysis has been carried out on the motivation and consequences of R&D manipulation. Integrating local government regulation and enterprise R&D manipulation into the same research system for inter-subject interaction analysis helps to fully understand sustainable innovation. (3) Based on the research results, this study proves that there is a "Win–Win Dilemma" between enterprises and local governments, while the intervention of central governments can effectively reduce the inaction of local governments to achieve sustainable development, providing a theoretical and practical basis for the reasonable setting and effective implementation of policies.

The remaining part of the paper proceeds as follows. Section 2 presents a literature review and proposes a research gap. Section 3 constructs the game model. Section 4 elaborates on the simulation experiment results. Section 5 discusses the results. Finally, Section 6 provides the conclusions and suggestions.

2. Literature Review

It is widely acknowledged in the academic community that innovation is a crucial driver of economic growth [27–32]. However, technological innovation and R&D activities can be incredibly complex. The nature of new technologies and knowledge as public goods means that economic agents may need help to fully capture the excess benefits, leading to a decline in the motivation to engage in R&D innovation [33–37]. As a result, many countries have implemented industrial policies, such as tax incentives and financial subsidies, to encourage enterprises to invest in R&D activities [38–40]. In 2008, China introduced the Measures for the Administration of High-Tech Enterprise Recognition to support the development of high-tech enterprises and promote R&D investment and technological innovation output. However, economic agents may exhibit different behaviors in response to national high-tech industrial policies. Enterprises incentivized by such

policies may prioritize strategic innovation over substantive innovation to meet policy requirements [41–44], and there have been cases of R&D manipulation [10]. In recent years, scholars have increasingly focused on R&D manipulation by enterprises, which is believed to be driven by policy dividend capture and financing constraints. Under policy orientation, financing constraints that previously limited enterprise development failed to reduce R&D manipulation and motivated covert R&D manipulation behaviors, resulting in lower productivity and profitability levels [24]. The two main types of R&D manipulation, "standard-achieving" and "tax-avoidance," both inhibit the incentive effect of industrial policy to improve the efficiency of enterprise technological innovation. The former is concentrated during the preliminary review of high-tech recognition, and the latter is concentrated during the review of high-tech recognition [45]. After the tax deduction policy was changed, enterprises' R&D manipulation behavior improved [46]. The recognition of high-tech status provides enterprises with preferential policies, which positively incentivize R&D input and output [47] and promote improving enterprises' total factor productivity [48]. However, R&D manipulation may negatively affect innovation efficiency [49], hinder the high-quality development of listed enterprises [50], and result in less improvement in the level of R&D investment and the quantity and quality of patents for enterprises that obtain high-tech status through R&D manipulation [51].

Moreover, R&D manipulation may increase enterprises' business risks and agency costs [52]. Effective corporate governance can help prevent R&D manipulation. An internationalized board of directors [53], accounting conservatism [14,54], the moderating role of political connections [55], analyst concern [56,57], and managerial and academic experience [58,59] can all play a role in inhibiting R&D manipulation from a corporate governance perspective. In addition, government regulation may provide a means to inhibit R&D manipulation [17,60].

Recognizing high-tech qualifications involves a game between local governments and high-tech companies seeking recognition. Financial constraints and political bonuses incentivize these enterprises to manipulate their R&D efforts to meet the recognition requirements. While local governments are expected to be impartial in recognizing high-tech qualifications, the current political tournament system [61] suggests that lenient supervision of R&D manipulation is likely due to considerations of local innovation performance, creating opportunities for rent-seeking by enterprises. Literature on the game between government regulation and firm R&D manipulation is limited [17,60]. China's economy has shifted from high-speed to high-quality development, and with the central governments' renewed focus on high-tech R&D manipulation since 2018, a new variable has been introduced to the game between local governments and high-tech enterprises seeking recognition.

Although most scholars have conducted a lot of research on R&D manipulation and have conducted sufficient theoretical research and exploratory analysis on the motivation, impact, and governance of R&D manipulation, there are still many deficiencies. (1) Many pieces of literature focus on the analysis of the effect of the R&D subsidy policy, and the analysis of corporate behavior under the R&D subsidy policy is insufficient; that is, it does not explain why an R&D subsidy policy with good intentions will lead to "R&D manipulation" after the implementation of the enterprise, and the motives behind the strategic choice of enterprises still need to be deeply explored. (2) Many works of literature on the governance of enterprise R&D manipulation start from the level of corporate governance and rarely mention the problem that local governments may ignore supervision for the sake of local innovation performance. On the one hand, if local governments increase their supervision over R&D manipulation, low-quality patent filings will decrease, which will reduce the performance evaluation of local government innovation indicators to a certain extent. On the other hand, if the local governments have weak supervision or no supervision over R&D manipulation, frequent incidents, such as "patent fraud" and "high-tech enterprise violation declaration and approval", will easily lead to "accountability" by central governments. Therefore, the motives behind the development of manipulation

games by local governments are also worthy of further investigation. (3) The literature on R&D manipulation behavior of enterprises through game theory is relatively scarce, and the existing literature generally only considers the two-game subjects of residents and the government, while ignoring China's special administrative structure and the decentralization relationship behind it. As a higher-level supervisory agency, the central governments can adopt various methods to supervise local governments and enterprises to ensure their compliance and fulfill their duties. Therefore, it is still worth considering whether the inaction of local governments and the R&D manipulation of enterprises can be improved when the central governments participate in regulation as a game player. In summary, this paper constructs a dual-scenario two-sided game model of whether the central governments will participate in the R&D manipulation of the under-rated enterprises and local government regulation. Through the simulation analysis, it reveals the degree and direction of the influence of each key variable on the strategy selection of different subjects. This paper seeks to improve the effectiveness of relevant departments in the regulation of R&D manipulation, maintain a fair competitive market environment, and promote sustainable economic and social development.

3. Model Construction

3.1. Description of the Game Model between Local Governments and High-Tech Enterprises

Consider a two-sided game system involving local governments and high-tech enterprises, such as in Figure 3. From the firm's perspective, the uncertainty of the innovation process, the solid positive externality, and the good public nature of the innovation results make it impossible for them to capture the total social value of their innovation efforts. Consequently, the willingness to invest in innovation is lower than social expectations, resulting in lower productive demand than social demand. Therefore, government agencies must incentivize innovative high-tech enterprises to encourage them to innovate.

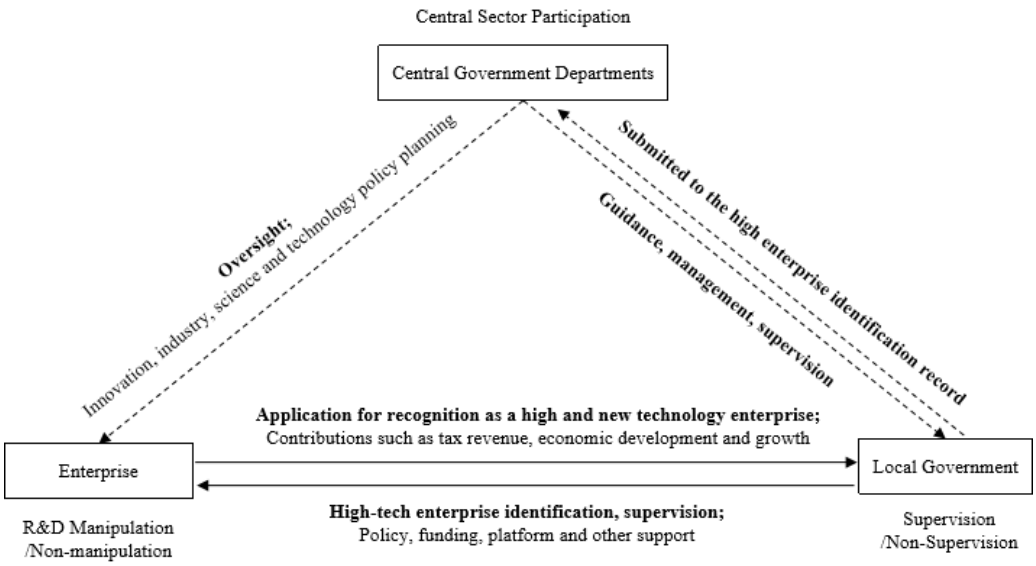

Figure 3. Government–Enterprise interaction.

From the perspective of local governments, an increase in the number of high-tech enterprise declarations translates to more qualified high-tech enterprises, which in turn enhances the innovation performance of the local area. However, due to severe information asymmetry and resources required to understand the status of HIEs' innovation activities, such as expending considerable human, material, and financial resources, local governments may need to pay more attention to R&D manipulation or adopt lax regulatory measures. Nevertheless, as public interest representatives, local governments may

choose to supervise the R&D manipulation of enterprises to fulfill their social governance responsibilities or out of fear of public and media exposure for failing to supervise.

When central governments' intervention is introduced, the two-dimensional game system between local governments and enterprises undergoes changes. Following the intervention of the central governments, local governments are subjected to heightened regulatory oversight and guidance emanating from the central authority. Consequently, there is a propensity for stricter enforcement of regulations and intensified monitoring of enterprises' activities.The power dynamics between local governments and enterprises undergo a transformative process as the central governments assume a more prominent and influential position. This paradigm shift often results in local governments experiencing diminished decision-making autonomy, compelling them to align their actions with the directives stipulated by the central governments. Consequently, the altered power dynamics can significantly impact the bargaining power and influence wielded by both local governments and enterprises.

3.2. Basic Assumptions

In this section, we introduce the hypotheses that underpin the interactive relationship between local governments and high-tech enterprises in the game system. These hypotheses lay the foundation for understanding the strategic decisions made by both parties and their limited rationality in the context of government regulation and corporate R&D manipulation.

Hypothesis 1. *Player. The game system includes two parties, the local governments and the high-tech enterprises seeking recognition, with the addition of central governments' supervision as exogenous variables.*

Hypothesis 2. *Strategy. Local governments may also choose to supervise or not to supervise for various reasons, such as promoting local innovation performance or fulfilling social governance responsibilities and public pressure. This constitutes the local government strategy (supervision or non-supervision). Assume that the local governments choose the strategy "supervision"; the probability is y, and the probability of choosing "non-supervision" is 1-y. High-tech enterprises may engage in R&D manipulation due to financial constraints and the desire to reap political bonuses to meet high-tech qualification requirements. Alternatively, they may choose not to manipulate R&D due to external regulations. This constitutes the firm's strategy (manipulation or non-manipulation). Assume that the enterprise chooses the strategy "manipulation"; the probability is x, and the probability of choosing "non-manipulation" is 1-x.*

Hypothesis 3. *Limited rationality. Local governments are comprised of groups of officials. In the competitive system of local decentralized political tournaments, different local governments vary in their attitudes toward R&D manipulation by high-tech enterprises. However, they also learn from each other, and there is limited rationality in their regulatory behavior. Similarly, high-tech enterprises exhibit limited rational behavior due to decentralized actions, insufficient information, and the profit motive, leading to obvious speculation, imitation, and experimentation. This paper employs a replicated dynamic model to represent the social learning mechanism of both sides of the game [62].*

Suppose the primary business income of the enterprises applying for high technology qualification is W, and the operating cost is C. Among them, the operating cost C is composed of two parts: the tax paid by the enterprises C_1 and other costs C_2. If the enterprise is awarded the high-tech enterprises qualification, they receive a certain tax reduction ratio α and the tax paid is $(1-\alpha)C_1$, where $\alpha\ in(0,1)$. When companies choose a "manipulation" strategy, a corresponding manipulation cost C_d is required, and the probability of successful filing is λ. When enterprises successfully declare the high-tech enterprises and patents, the innovation index of local governments increases, and the government innovation performance G_s is obtained. When the enterprises in the jurisdiction

want to use "R&D manipulation" to receive the qualification of high-tech enterprises, the number of declared high-tech enterprises increases. The number of high-tech enterprises increases accordingly, then the government innovation performance becomes $(1+\gamma)G_s$, where γ is the intensity of R&D manipulation and the higher the value larger the value of manipulation intensity, the more serious the R&D manipulation phenomenon in the region. The local governments, as a representative of public interest, are concerned about the public and media exposure of the R&D manipulation phenomenon due to the responsibility of social governance, so they regulate the enterprises' R&D manipulation phenomenon. They invest the cost of regulation S. If the enterprises declaring high technology qualifications adopt the "manipulation" strategy, they will face the risk of government penalties, and the risk cost is $\gamma\lambda F$.

Table 1 lists the parameters we will use and their meanings.

Table 1. The parameters in the payment matrix and their meanings.

Variables	Meaning
W	Revenue from main business
C_1	Corporate taxation
C_2	Other costs
α	Tax reduction ratio
C_d	Manipulation costs
λ	Probability of success in filing
G_s	Innovation performance
γ	R&D manipulation intensity
S	Government regulatory input
F	Cost of enterprise risk
σ	Probability of supervision by higher authorities
F_c	The cost of risk for high-tech enterprise under the higher-level regulation
F_g	The cost of risk for local governments under higher-level regulation

3.3. Model Stability Analysis under the Involvement Scenario of No Central Governments

According to the above assumptions and parameter settings, combined with the strategies of local governments and high-tech enterprises, we can observe the following four scenarios: (Manipulation, Supervision), (Non-Manipulation, Supervision), (Manipulation, Non-Supervision), (Non-Manipulation, Non-Supervision).

The payment matrix in Table 2 is based on the above analysis of the benefits to both parties.

Table 2. No central government supervision of local governments and to-be-evaluated high-tech enterprises game payment matrix.

		Local Governments	
		Supervision (y)	**Non-Supervision (1− y)**
High-Tech Enterprises	Manipulation (x)	$(W-(1-\lambda\alpha)C_1-C_2-C_d-\gamma\lambda F,$ $G+G_s+(1-\lambda\alpha)C_1-S+\gamma\lambda F)$	$(W-(1-\lambda\alpha)C_1-C_2-C_d,$ $G+(1+\gamma)G_s+(1-\lambda\alpha)C_1)$
	Non-Manipulation (1 − x)	$(W-C_1-C_2, G+C_1-S)$	$(W-C_1-C_2, G+C_1)$

Let the expected benefits of "manipulation" and "non-manipulation" of high-tech enterprises be denoted by U_x^1 and U_x^2, respectively, and the average benefit be denoted by $\overline{U}_x$. Similarly, let the expected benefits for local governments of "supervision" and "non-supervision" be denoted by U_y^1 and U_y^2, respectively, and the average benefit be denoted by $\overline{U}_y$. By constructing a game payment matrix for both sides, we can obtain the two-

dimensional game dynamics system for local governments and high-tech enterprises as Equation (1):

$$\begin{cases} F_1(x) = \dfrac{dx}{dt} = x(U_x^1 - \overline{U}_x) = x(1-x)(U_x^1 - U_x^2) \\ F_1(y) = \dfrac{dy}{dt} = y(U_y^1 - \overline{U}_y) = y(1-y)(U_y^1 - U_y^2) \end{cases} \tag{1}$$

Make $F_1(x) = 0$,$F_1(y) = 0$. The game system can be obtained with five equilibrium points, which are $E_1(0,0)$, $E_2(0,1)$, $E_3(1,0)$, $E_4(1,1)$, and $E^*(x^*,y^*)$, among them $x^* = \frac{S}{\gamma\lambda F - \gamma G_s}$ and $y^* = \frac{\lambda\alpha C_1 - C_d}{\gamma\lambda F}$. The Jacobi matrix of the two-dimensional game system between local governments and high-tech enterprises without the participation of higher authorities is:

$$J_1 = \begin{bmatrix} (1-2x)(\lambda\alpha C_1 - C_d - \gamma\lambda F y) & x(1-x)(-\gamma\lambda F) \\ y(1-y)(\gamma\lambda F - \gamma G_s) & (1-2y)(x(\gamma\lambda F - \gamma G_s) - S) \end{bmatrix}$$

According to Friedman's method, if the equilibrium point is such that the Jacobi matrix of the game system satisfies $Det(J_1) > 0, Tr(J_1) < 0$, it becomes the local stability point and serves as the stable strategy for the system's evolution (ESS). The stability of the game model is determined based on the following three scenarios in Table 3. ($E^*(x^*,y^*)$ is always a saddle point, so not listed in the Table 3.

Table 3. Stability of both sides of the game in the case of no central government involvement.

	Situation 1			Situation 2			Situation 3		
	$\lambda\alpha C_1 - C_d < \gamma\lambda F$, $\gamma\lambda F - \gamma G_s < S$			$\lambda\alpha C_1 - C_d > \gamma\lambda F$, $\gamma\lambda F - \gamma G_s < S$			$\lambda\alpha C_1 - C_d > \gamma\lambda F$, $\gamma\lambda F - \gamma G_s > S$		
Point	$Det(J)$	$Tr(J)$	Equalization	$Det(J)$	$Tr(J)$	Equalization	$Det(J)$	$Tr(J)$	Equalization
$E_1(0,0)$	−	Uncertain	Unstable	−	Uncertain	Unstable	−	Uncertain	Unstable
$E_2(0,1)$	−	Uncertain	Unstable	+	+	Unstable	+	+	Unstable
$E_3(1,0)$	+	−	ESS	+	−	ESS	−	Uncertain	Unstable
$E_4(1,1)$	+	+	Unstable	−	Uncertain	Unstable	+	−	ESS

Let $\Delta Pf_x^1 = \lambda\alpha C_1 - C_d - \gamma\lambda F$ portray the relative net returns of enterprises choosing different strategies, and let $\Delta Pf_y^1 = \gamma\lambda F - \gamma G_s - S$ portray the relative net returns of local governments choosing different strategies.

Situation 1: When $\Delta Pf_x^1 < 0$ and $\Delta Pf_y^1 < 0$, following the instinct of the profit-seeking effect of companies, they should choose not to conduct R&D manipulation to avoid the costs of regulatory risk. However, $\Delta Pf_y^1 < 0$ local governments may choose not to regulate due to the significant innovation performance resulting from the high-tech qualification. Because the system is a repeated game model, the evaluated high-tech enterprises are bound to adopt speculative strategies when they obtain information about the decreasing probability of government regulation.

Situation 2: When $\Delta Pf_x^1 > 0$ and $\Delta Pf_y^1 < 0$, high-tech enterprises choose to have positive relative net profits for R&D manipulation compared to no manipulation and thus have strong incentives to capture policy dividends. However, in the case of $\Delta Pf_y^1 < 0$, local governments may be negligent in supervising the phenomenon of R&D manipulation, which may lead to the flourishing of the speculative culture of enterprises in the region and create confusion in the management of high-tech enterprises.

Situation 3: When $\Delta Pf_x^1 > 0$ and $\Delta Pf_y^1 > 0$, local governments tighten their regulation on R&D manipulation. However, the high-tech enterprises to be evaluated have a solid incentive to manipulate R&D for profit. Even if the government tightens its regulation, as long as high-tech enterprises can obtain significant profits from R&D manipulation, they will continue to engage in it to obtain high-tech enterprise qualifications.

3.4. Model Stability Analysis in the Case of Involvement Scenario of Central Governments

The higher authorities will monitor the R&D manipulation and government inaction of enterprises and will expose the problems or issue documents to request local governments to conduct self-examination. Therefore, high-tech enterprises not only face the supervision of local governments when conducting R&D manipulation but also face the supervision of higher-level government departments. The game matrix between the local governments and the high-tech enterprises will be changed, as shown in Table 4.

Table 4. The payment matrix of the game in the case of central governments.

		Local Governments	
		Supervision (y)	**Non-Supervision (1 − y)**
High-Tech Enterprises	Manipulation (x)	$(W-(1-\lambda\alpha)C_1-C_2-C_d-\gamma\lambda F-\delta\gamma F_c, G+G_s+(1-\lambda\alpha)C_1-S+\gamma\lambda F)$	$(W-(1-\lambda\alpha)C_1-C_2-C_d-\delta\gamma F_c, G+(1+\gamma)G_s+(1-\lambda\alpha)C_1-\delta\gamma F_g)$
	Non-Manipulation (1 − x)	$(W-C_1-C_2, G+C_1-S)$	$(W-C_1-C_2, G+C_1-\delta\gamma F_g)$

Let the expected benefits of "manipulation" and "non-manipulation" of high-tech enterprises be denoted by R_x^1 and R_x^2, respectively, and the average benefit be denoted by $\overline{R}_x$. The expected benefits of "supervision" and "non-supervision" for local governments be denoted by R_y^1 and R_y^2, respectively, and the average benefit be denoted by $\overline{R}_y$. With the participation of higher authorities, the two-dimensional game dynamics system consisting of local governments and high-tech enterprises is as Equation (2):

$$\begin{cases} F_2(x) = \dfrac{dx}{dt} = x(R_x^1 - \overline{R}_x) = x(1-x)(R_x^1 - R_x^2) \\ F_2(y) = \dfrac{dy}{dt} = y(R_y^1 - \overline{R}_y) = y(1-y)(R_y^1 - R_y^2) \end{cases} \tag{2}$$

in the case of higher authorities involvement, the Jacobi matrix of the two-dimensional game system between local governments and high-tech enterprises is:

$$J_2 = \begin{bmatrix} (1-2x)(\lambda\alpha C_1 - C_d - \delta\gamma F_c - \gamma\lambda F y) & x(1-x)(-\gamma\lambda F) \\ y(1-y)(\gamma\lambda F - \gamma G_s) & (1-2y)(\delta\gamma F_g - S + x(\gamma\lambda F - \gamma G_s)) \end{bmatrix}$$

It is evident that with the oversight of higher authorities in the game between local governments and high-tech enterprises, R&D manipulation becomes more difficult for the latter, as their previously-shared interests with the former no longer hold. Specifically, when local governments choose a supervision strategy, it results in $\lambda\alpha C_1 - C_d - \delta\gamma F_c - \gamma\lambda F < 0$. If local governments do not regulate, they will be held accountable or even punished, with the added risk of higher-level oversight costs. Similarly, if a high-tech enterprise to be evaluated chooses to manipulate R&D, it results in $S - \delta\gamma F_g + \gamma G_s - \gamma\lambda F < 0$. The evolutionary stability of the system in this case depends on two main points: (1) The enterprise pays the net profit under the supervision of the central governments $\Delta P f_x^2 = \lambda\alpha C_1 - C_d - \delta\gamma F_c$. (2) The local governments pay the net profit under the supervision of the central governments $\Delta P f_y^2 = \delta\gamma F_g - S$. The stability of the game model is determined from the following three scenarios, as shown in Table 5.

Table 5. Stability of both sides of the game in the case of central government involvement.

	Situation 4			Situation 5			Situation 6		
	$\lambda\alpha C_1 - C_d - \delta\gamma F_c < 0$, $\delta\gamma F_g - S < 0$			$\lambda\alpha C_1 - C_d - \delta\gamma F_c < 0$, $\delta\gamma F_g - S > 0$			$\lambda\alpha C_1 - C_d - \delta\gamma F_c > 0$, $\delta\gamma F_g - S > 0$		
Point	$Det(J)$	$Tr(J)$	Equalization	$Det(J)$	$Tr(J)$	Equalization	$Det(J)$	$Tr(J)$	Equalization
$E_1(0,0)$	+	−	ESS	−	Uncertain	Unstable	+	+	Unstable
$E_2(0,1)$	−	Uncertain	Unstable	+	−	ESS	+	−	ESS
$E_1(1,0)$	−	Uncertain	Unstable	+	+	Unstable	−	Uncertain	Unstable
$E_1(1,1)$	−	Uncertain	Unstable	−	Uncertain	Unstable	−	Uncertain	Unstable

Situation 4: When $\Delta Pf_x^2 < 0$ and $\Delta Pf_y^2 < 0$, the relative net profit of a high-tech enterprise manipulating R&D and not manipulating R&D is negative, the enterprise will choose not to manipulate R&D. Local governments will choose a non-supervision strategy as the relative net benefit of choosing a supervision versus non-supervision strategy is harmful. However, without local government regulation, high-tech enterprises may resort to speculation. With central government involvement in regulation, high-tech enterprises will refrain from engaging in speculative behavior as they still face potential risks despite the low probability of being subject to local government oversight. The net returns of both strategies, manipulation, and non-manipulation, for high-tech companies are still negative, which is far from ideal. This essentially shifts the responsibility of local regulation to the central governments, which usually invest more in regulating local affairs than local governments.

Situation 5: When $\Delta Pf_x^2 < 0$ and $\Delta Pf_y^2 > 0$, the relative net payments of the two strategies of manipulation and non-manipulation by high-tech enterprises to be evaluated are negative, and the enterprises' self-interest will drive them to choose not to engage in R&D manipulation. For local governments, the relative net benefits of choosing a regulation strategy and a non-regulation strategy are positive, and local governments will choose the regulation strategy to reach the evolutionary stability point (Non-Manipulation, Supervision). There are two reasons for the local governments to choose the regulatory strategy. Firstly, while the gain of the local governments in choosing the regulatory strategy, in this case, may not be positive, the gain of the local governments when they choose not to regulate is even worse under the supervision pressure of higher authorities. Secondly, according to the current system in China, local governments have no choice if the central government requests rectification. This situation is a more desirable stable state for the game system of both local governments and high-tech enterprises.

Situation 6: When $\Delta Pf_x^2 > 0$ and $\Delta Pf_y^2 > 0$, it implies that the relative net profits of performing R&D manipulation versus not manipulating R&D are negative for high-tech enterprises; thus, high-tech enterprises will choose R&D manipulation strategies. Meanwhile, local governments are likely to opt for monitoring strategies. However, the strategy (manipulation, supervision) is not an evolutionary stable strategy. Although high-tech enterprises may engage in R&D manipulation in a single game, local governments will always choose to supervise the strategy in repeated games. As a result, the interest structure of high-tech enterprises changes, leading to negative relative net profits for both manipulation and non-manipulation strategies. Consequently, high-tech enterprises will shift their strategy and choose not to engage in R&D manipulation.

4. Simulation Experiments

To find the local evolutionary stability solution closest to the real situation, this study conducted extensive research by visiting more than 20 high-tech enterprises (including both qualified and to-be-evaluated ones) located in a high-tech zone in a city. Based on field research results, expert discussion, and stability analysis results, the following parameters were set: $C_1 = 10$, $\alpha = 0.4$, $C_d = 0.8$, $\lambda = 0.4$, $G_s = 2$, $\gamma = 0.5$, $S = 0.5$, $F = 4.2$, $\sigma = 0.5$, $F_c = 4$, $F_g = 1.5$. To ensure the accuracy of the experiment and prevent random errors, each simulation was run 50 times and the average value was taken as the experimental result.

4.1. The Effect of Corporate Taxation C_1 on the Strategies of Game Subjects

Changes in corporate taxes affect the strategic evolution of local governments and enterprises concerning the direction and speed of convergence to evolutionarily stable strategies. Regarding directions, the probability of local governments choosing to regulate continuously approaches 0 as the corporate tax rate increases. For high-tech enterprises, there is a tax threshold. When the tax rate exceeds the threshold, high-tech enterprises choose the "manipulation" strategy and converge to 1. Otherwise, they choose the "non-manipulation" strategy and converge to 0. As shown in Figure 4. (Two diagrams are used here, and the larger one is part of the smaller one, which is done to understand the evolutionary game process more clearly.

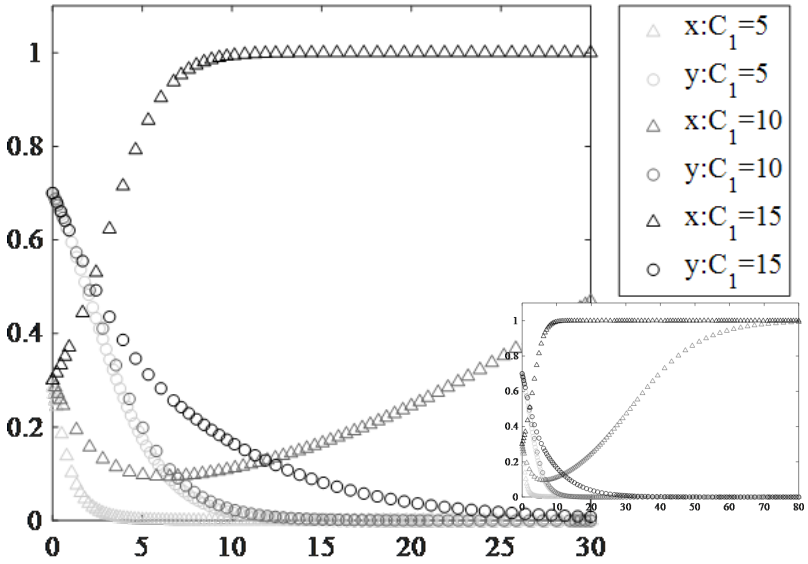

Figure 4. The effect of corporate taxation on the strategies of game subjects.

Regarding convergence speed, the rate at which local governments converge to the regulation strategy gradually decreases with increasing corporate tax revenue. In contrast, high-tech enterprises to be evaluated initially converge rapidly to a stable strategy, then converge slowly, and finally accelerate their convergence. Overall, high-tech enterprises are more sensitive to changes in tax rates, while local governments exhibit differences mainly in the speed of convergence.

4.2. The Effect of Regional R&D Manipulation Intensity γ on the Strategies of Game Subjects

The local governments are not sensitive to the intensity of regional R&D manipulation, as the evolutionary stability strategy and the convergence rate are almost unaffected. As the intensity of regional R&D manipulation increases, the rate of convergence of the "manipulation" strategy chosen by the high-tech enterprises to converge to 1 gradually decreases, highlighting the need for the intervention of higher regulatory authorities. It is important to note that in an environment full of unfair competition, the profit-seeking instincts of corporate entities cannot be solely blamed. Instead, part of the blame should be placed on the local government's connivance with corporate R&D manipulation, resulting in management confusion and increased regulatory costs. Interestingly, when the intensity of regional R&D manipulation increases, convergence speed to the "manipulation" strategy decreases. This indicates that all the high-tech enterprises to be evaluated choose R&D manipulation to increase the degree of involution, leading to the need for them to pay more to obtain policy dividends, as shown in Figure 5.

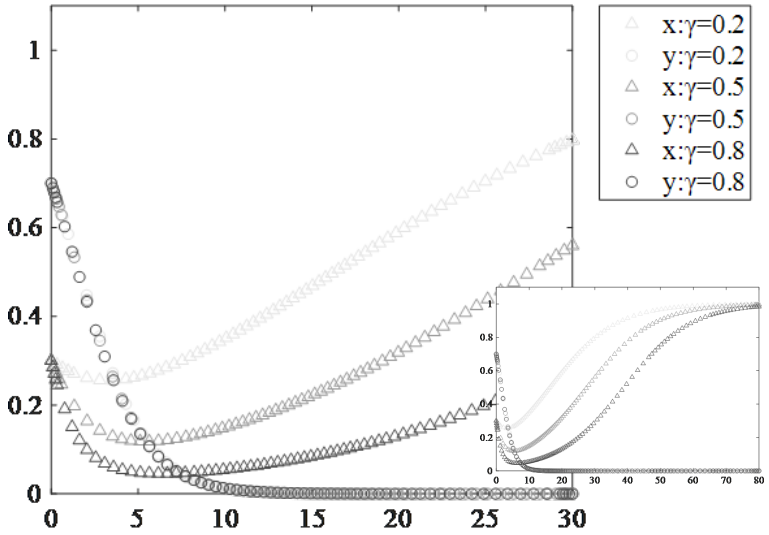

Figure 5. The effect of regional R&D manipulation intensity on the strategies of game subjects.

4.3. The Effect of Government Innovation Performance G_s on the Strategies of Game Subjects

The likelihood of local government regulation of R&D manipulation by enterprises decreases with more extraordinary innovation performance, while the effect on high-tech enterprises is mainly in the convergence rate. When local government innovation performance reaches a critical value, the probability of non-regulation by local governments converges to 1 if the innovation performance exceeds the critical value and converges to 0 if it does not. Meanwhile, the probability of high-tech enterprises choosing the "R&D manipulation" strategy converges to 1 with greater speed, as shown in Figure 6. This suggests that local governments that place too much emphasis on innovation performance may be more likely to regulate R&D manipulation negatively. However, current performance appraisal systems rely heavily on indicators such as the number of high-tech enterprises and patents, as observed from the existing literature [41,62], which may not fully reflect actual innovation performance. Therefore, central governments should be supposed to pay a key role in regulating, which will be analyzing in the following sections.

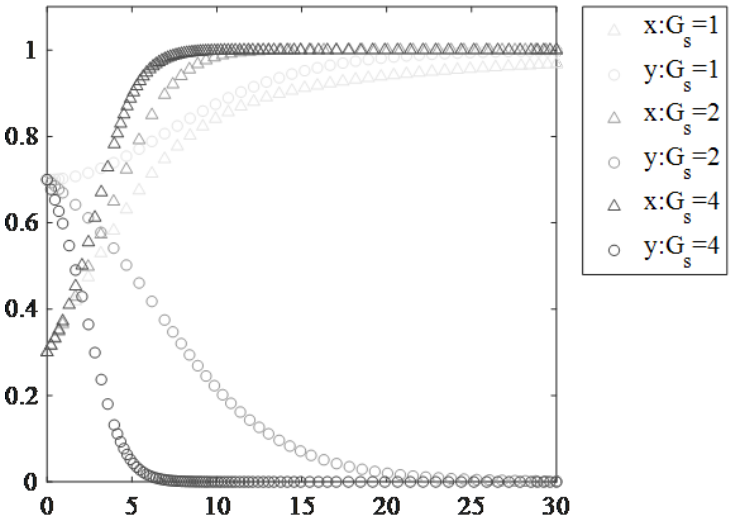

Figure 6. The effect of government innovation performance on the strategies of game subjects.

4.4. The Effect of Government Regulatory Costs S on the Strategies of Game Subjects

There is a direct relationship between the input cost of local governments to implement regulation and the probability of local governments not regulating the enterprise. As the

cost of regulation increases, local governments become less likely to regulate and more likely to converge towards the strategy of "Non-Supervision". Figure 7 shows that there is a critical value for local governments' regulation cost, where above this value, the willingness of not regulating for local governments will converge to 1. Otherwise, it will converge to 0. Furthermore, as regulation costs increase, the probability of high-tech enterprises using the "R&D manipulation" strategy increases and converges faster to 1. This indicates that local governments may be irrational in dealing with local issues and are willing to invest only a small amount in regulatory costs, leading to a rapid convergence towards the "R&D manipulation" strategy. This, in turn, leads to higher regulatory costs for local governments to eliminate R&D manipulation, and they may choose the "no regulation" strategy, which leads to a convergence towards the "R&D manipulation" strategy. External intervention and coercion may be significant to avoid this "Win–Win Trap", including the trap of local government's inaction and the proliferation of R&D manipulation by the high-tech enterprises to be evaluated.

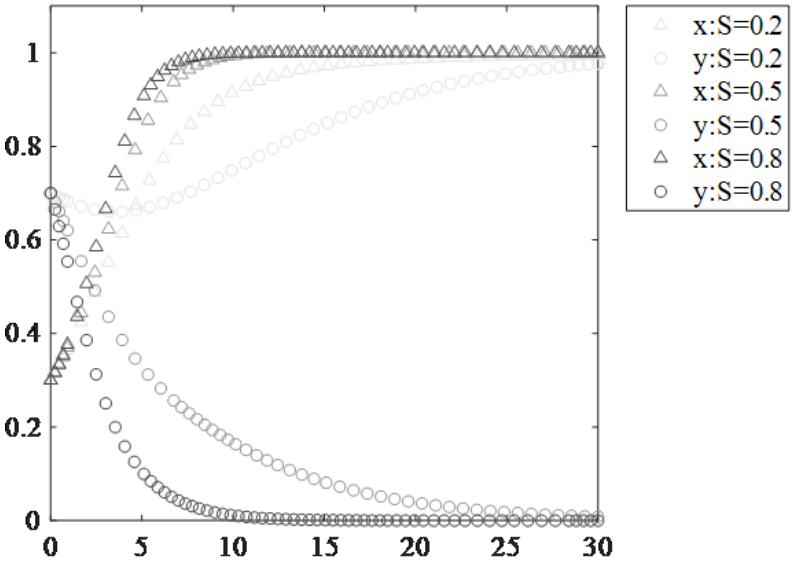

Figure 7. The effect of government regulatory costs on the strategies of game subjects.

4.5. The Effect of Central Governments' Supervisory Probability σ on the Strategies of Game Subjects

This is clear evidence that the intervention of higher regulatory authorities plays an essential role in regulating R&D manipulation by high-tech enterprises. When the probability of regulation by higher authorities increases, the local government's willingness to regulate also increases, leading to a change in the ESS strategy of high-tech enterprises from "manipulation" to "non-manipulation." Figure 8 shows that when the probability of regulation by higher authorities is 0.5, the probability of local governments choosing "Supervision" or "Non-Supervision" remains the same as the initial probability. However, when the probability of regulation by higher authorities is less than 0.5, the probability of local governments choosing "Supervision" increases as the probability of regulation by higher authorities increases along with the probability of high-tech enterprises choosing the "manipulation" strategy converges to 0, with an increasing convergence speed. This implies that when the higher regulatory authority intervenes, the local governments will make corresponding adjustments in response to the movement of the higher authority. Under the pressure of double regulation, the strategy choice of high-tech enterprises fundamentally changes, with the probability of choosing the "manipulation" strategy decreasing from 1 to 0.

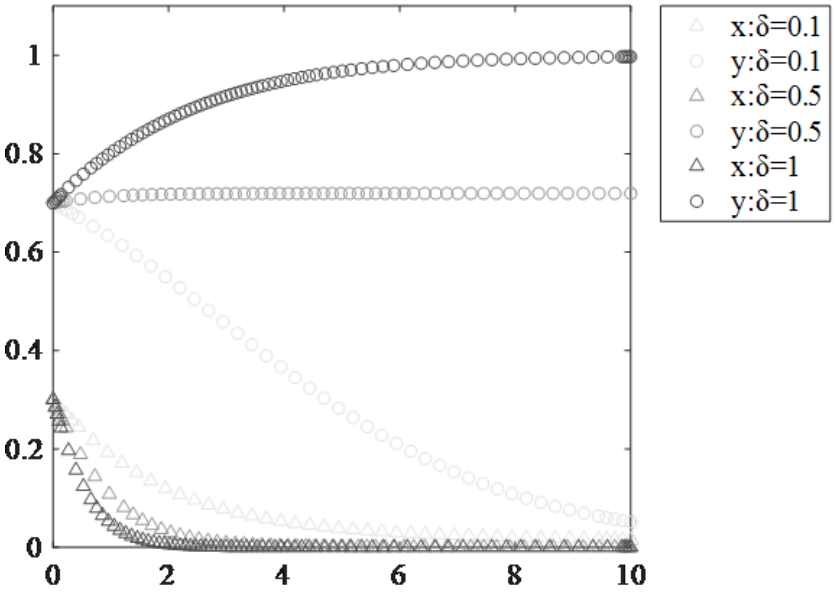

Figure 8. The effect of central governments' supervisory probability on the strategies of game subjects.

4.6. The Impact of Risk Cost on the Strategy of Game Subjects in the Case of Superior Sector Regulation

When central governments intervene in the evolutionary game between local governments and high-tech enterprises, the high-tech enterprises to be evaluated not only face the supervision of the local governments but also need to face the risk of supervision by the higher authorities. Therefore, the risk cost for choosing the "R&D manipulation" strategy increases, eventually stabilizing at the "no manipulation" strategy. As shown in Figure 9, the probability of choosing a "manipulation" strategy increases when the risk of supervision by higher authorities is low, and eventually stabilizes at the "no manipulation" strategy when it reaches a critical value. This reflects that even when higher authorities regulate R&D manipulation, high-tech enterprises are still incentivized to choose the "manipulation" strategy to gain policy benefits.

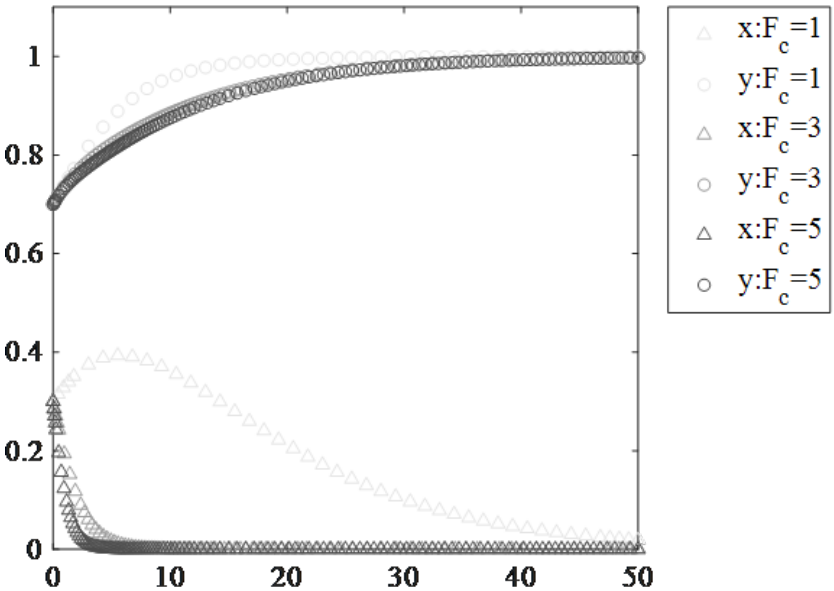

Figure 9. The impact of enterprise risk costs on the strategies of game subjects.

As the risk cost of regulation by higher authorities increases for local governments, the probability of them choosing to regulate also increases. However, high-tech enterprises' likelihood of choosing the "manipulation" strategy always converges to 0. When the risk cost of regulation by higher authorities is 2, the probabilities of local governments choosing "Supervision" and "Non-Supervision" will remain the same as their initial probabilities. However, when the probability of regulation by higher authorities exceeds 2, the probability of local governments choosing "Supervision" will converge to 1 at a relatively fast rate, while the probability of them choosing "Non-Supervision" will converge to 0 at a relatively slow rate. As shown in Figure 10. When local governments face a higher cost of risk, local governments may be more cautious and disciplined in their regulatory responsibilities. They may strengthen their regulation of enterprises to avoid conflicts with the central governments or taking unnecessary risks. However, from Figure 9, there is a risk threshold, and when the cost of risk to local governments is less than the threshold, local governments tend to deregulate. In addition, enterprises will pay more attention to complying with the central government's rules and requirements to avoid being regulated by both the central and local governments, thus taking the associated risks and penalties. In addition, enterprises may be more cautious in evaluating and managing partnerships with local governments to reduce possible risks.

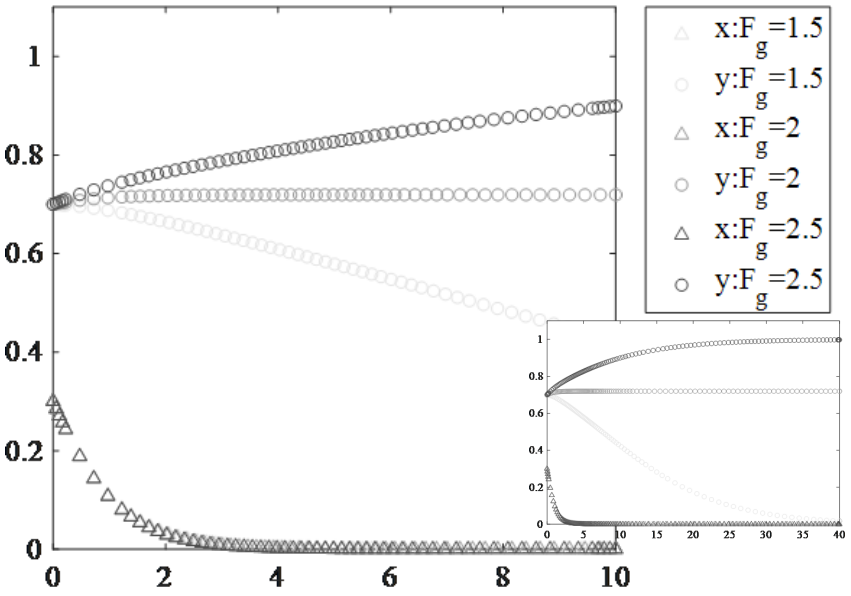

Figure 10. The impact of government risk costs on the strategies of game subjects.

5. Discussion

Judging by the current practical experience, local governments still have insufficient and inadequate supervision of enterprises' R&D manipulation, which seriously affects the innovation vitality and development opportunities of enterprises and damages social and economic benefits. However, the existing literature on the R&D manipulation game behavior of local governments and enterprises is insufficient to explain the regulatory mechanisms and policy tools that the central governments participate in. Given this, this study constructed an evolutionary game model composed of local governments and high-tech enterprises to be evaluated around the issue of R&D manipulation and introduced an evolutionary game model based on objective facts by the superior government to intervene in the supervision of both parties. Through the stability analysis of the equilibrium solution, this paper analyzed the different strategic choices of high-tech enterprises under evaluation and local governments in the face of R&D manipulation under different circumstances. The research results will lead to a re-examination of the perspective of R&D manipulation, making up for the shortcomings of previous studies that mainly focus on market players and ignore local governments. There are several important findings in the study.

(1) The government's that increase corporate taxation is conducive to increasing the probability of local governments supervising the phenomenon of R&D manipulation in the region, but it will also dampen the enthusiasm of enterprises for innovation, which is not conducive to releasing the vitality of enterprises. Firstly, increasing corporate taxation will increase the burden on enterprises and reduce the funds that enterprises can use for R&D and innovation. Innovation requires a large amount of capital investment, including expenditure on R&D equipment, personnel training, and marketing. If a company faces a higher tax burden, it will weaken its ability and enthusiasm to invest in innovation. Secondly, increasing corporate taxation may lead to an increase in corporate costs, putting them at a disadvantage in market competition. When enterprises face high tax pressure, they may have to reduce expenditures in other areas, such as R&D investment, employee compensation, market expansion, etc., which will affect the innovation ability and competitiveness of enterprises. However, while central governments reduce taxes for enterprises, they need to pay close attention to the phenomenon of "inaction" such as negative supervision brought about by tax cuts by local governments. Because the implementation of the tax cut policy may reduce the fiscal revenue of local governments, thereby affecting their regulatory and service capabilities.

(2) Local governments are not sensitive to changes in the intensity of regional R&D manipulation. On the one hand, local governments are related to the interests of enterprises in regional economic development. To fulfill their performance appraisal requirements, local governments hope to attract more business investment and R&D activities to drive economic growth and employment opportunities. In this case, local governments may take a more relaxed stance on the issue of R&D manipulation to avoid negative impacts on business development. This interest correlation may lead to local governments being less sensitive to changes in regional R&D manipulation intensity. On the other hand, local governments may face resource constraints and lack sufficient human, material, and financial resources to monitor and evaluate R&D activities. Regulatory work requires extensive data collection, analysis, and tracking, as well as investigation and audit of corporate behavior. If local governments have resource constraints, it will affect their sensitivity to changes in the intensity of R&D manipulation and their ability to monitor. Therefore, this requires the timely intervention of the central governments, which not only regulates the R&D behavior of enterprises but also provides a more objective and impartial perspective to ensure the fairness and impartiality of regulatory work and maintain market order and public interest.

(3) The higher the innovation performance of the local government and the greater the regulatory cost, the easier it is for it to fall into the "Win–Win Trap" with the high-tech enterprises to be evaluated. Regarding innovation performance, on the one hand, local governments' promotion and assessment requirements make local governments pay more attention to the improvement of innovation performance. While requiring enterprises to increase R&D activities, they may turn a blind eye to enterprises' R&D manipulation behavior or adopt loose regulatory policies, thus increasing enterprises' R&D activities, possibility of manipulation. On the other hand, when the innovation performance of the local government is higher, the pressure they face in performance appraisal and evaluation may be reduced. This may lead to a decline in the initiative of local governments in regulating corporate R&D manipulation, and no longer regard it as a priority task. Local governments may pay more attention to political performance in other fields, but have insufficient investment in the supervision of enterprise R&D manipulation. Regarding the cost of supervision, local governments have irrational behaviors. Local governments may be limited by resources and manpower, and are only willing to invest a small regulatory cost, but this may lead to insufficient supervision and make it easy for companies to take actions to manipulate R&D for personal or corporate benefit. When the local governments realize that the existence and impact of R&D manipulation may need to invest more regulatory costs to curb, it weighs the gains and losses and chooses to give up regulating. For example, increasing regulatory costs may lead to excessive consumption of government

resources, and there is no guarantee that the occurrence of manipulative R&D behavior will be completely eliminated. The emergence of this circular effect also requires the intervention of the central governments to effectively curb R&D manipulation.

(4) After the higher-level supervision department intervenes in the game system, it can reverse the "manipulation" strategy of high-tech enterprises to be evaluated, and can also improve the choice of "supervision" strategy by local governments. Firstly, the intervention of higher-level regulatory authorities can strengthen the supervision of local governments and enterprises. By formulating stricter regulatory policies, strengthening law enforcement, and providing more resource support, higher-level regulatory authorities can strengthen the crackdown on corporate R&D manipulation. This will allow high-ranking companies to realize that adopting "manipulation" strategies may face higher risks and costs, thereby reducing the occurrence of their manipulation. Secondly, higher-level regulatory authorities can encourage local governments to actively perform regulatory responsibilities by establishing an effective incentive mechanism. This could include providing rewards and promotion opportunities, and setting evaluation indicators to incentivize local governments to more actively monitor corporate behavior. When local governments realize that the positive performance of supervision will be rewarded and recognized, they are more motivated to strengthen the supervision of enterprises and reduce the occurrence of R&D manipulation. Thirdly, higher-level regulators can facilitate information sharing and cooperation among local governments and high-tech enterprises. By building closer partnerships and sharing information and experiences on corporate R&D manipulation, local governments can better understand and respond to these problems. Sharing information and cooperating can also increase the effectiveness and efficiency of regulators, making them more capable of responding to corporate R&D manipulation.

6. Conclusions and Recommendations

6.1. Conclusions

Based on the basic framework of the two-dimensional evolutionary game between the government and enterprises, this paper constructs a two-scenario model of whether the central governments intervene in the evolutionary game between local governments and high-tech enterprises in innovation manipulation, and explores the local optimization strategy of the inconsistency between policy expectations and implementation results caused by the heterogeneity of central and local government goals. The study found that enterprises are prone to R&D manipulation to meet the threshold standards in the high-tech qualification certification, and the government is prone to lax supervision of R&D manipulation to complete its local performance considerations. Changes in taxation, government innovation performance, and government regulatory costs will all have an impact on corporate R&D manipulation and government regulation, while government regulation is not sensitive to changes in the strength of regional R&D manipulation. In the scenario where the central governments participate, due to the influence of enterprise risk cost and government risk cost, enterprise R&D manipulation will be reduced, and local government regulation will be strengthened.

6.2. Theoretical Implications

Although the issues associated with R&D manipulation have been well studied, the present work still has some novel theoretical implications. First of all, this paper conducts a comprehensive analysis of the motives of corporate R&D manipulation and the reasons why local governments do not act in supervision, providing a theoretical basis for the establishment of a national innovation system and the implementation of sustainable innovation strategies. Secondly, this paper considers the behavior strategy choices of local government regulation and enterprise R&D manipulation in the context of central government supervision under Chinese-style decentralization. The evolutionary game involves many aspects such as power distribution, resource allocation, and interest game, revealing the complexity and dynamics of political and economic relations. Finally, the

study of evolutionary games can help to expand and enrich the theoretical framework. This kind of game involves the interests and behaviors of different subjects, which can promote the development and expansion of related theories, such as political economy, organizational behavior, public management, and other fields, and provide new research perspectives and theoretical support for the academic community.

6.3. Practical Implications

This study provides the following practical implications. Firstly, through the in-depth study of the evolutionary game, the influencing factors of corporate R&D manipulation behavior in the innovation environment can be identified and resolved. This will help to propose corresponding policies and measures, encourage the development of innovative activities, and promote scientific and technological progress and economic development. Secondly, the study of the evolutionary game is helpful to strengthen the ability and level of government supervision. By understanding the characteristics and motivations of R&D manipulation, as well as the roles and responsibilities of local and central governments in supervision, local governments can improve supervision mechanisms and means, reduce the occurrence of manipulation, and maintain market order and fair competition. Thirdly, the study of evolutionary games helps to clarify the roles and responsibilities of local government and central government in innovation management. Clarifying the division of powers and responsibilities of governments at all levels and the coordination mechanism can promote the government to play an efficient role in innovation and development, thereby promoting coordinated economic and social development. Finally, studying the evolutionary game is helpful to promote policy coordination and coordination. A clear understanding of the relationship between all parties can effectively coordinate the conflicts and contradictions among different subjects, thereby forming an integrated policy framework, which is conducive to the full implementation of various policies.

6.4. Recommendation

The above research results validate the core theoretical assumptions of this paper and provide important insights into the central governments' regulatory policy practice and related institutional arrangements. This paper proposes the following policy recommendations.

(1) Strengthen the effective identification of innovation activities. The governments formulate clear guidelines for the evaluation of innovation projects, including the requirements for technological innovation and the rationality of R&D investment, to conduct scientific and objective evaluation and identification of enterprise innovation. The governments should strengthen publicity and education for enterprises and relevant stakeholders, raise awareness and vigilance against R&D manipulation, strengthen compliance training within enterprises, and guide enterprises to carry out innovation activities reasonably.

(2) Improve the formulation of preferential tax policies. In response to corporate R&D manipulation, governments can adopt differentiated tax policies to increase the tax burden on R&D projects that have not been fully reviewed or have signs of manipulation, to reduce the incentives and profit margins of companies to engage in manipulation. The governments have established a strict R&D expenditure review system, and through the review and deduction mechanism, ensures that companies can only declare compliant and authentic R&D expenditures, thereby reducing the occurrence of R&D manipulation.

(3) Strengthen the design of assessment indicators. The central governments can re-examine the promotion assessment indicators of local governments, incorporate the effectiveness and effectiveness of R&D manipulation supervision into the assessment indicator system, and ensure that local governments take active and effective regulatory measures against R&D manipulation during promotion assessments.

(4) Strengthen supervision and evaluation. The central governments can increase its supervision of local governments and conduct regular assessments and inspections to ensure that local governments fulfill their supervisory responsibilities and promptly detect and correct R&D manipulation. At the same time, the central governments should

promptly supervise and rectify local governments with weak supervision, and conduct follow-up evaluations.

6.5. Limitations

Finally, this paper has some unresolved issues that can be used as future research directions. (1) In terms of simulation data in this paper, the research conclusions will be more reliable if actual data based on real cases can be found for simulation. In addition, the comparison of simulation scenarios under multiple numerical combinations is also the direction of subsequent research in this paper. (2) The variable design in this paper is based on the assumptions of common scenarios, and there are inevitably other variables in reality that are not taken into consideration, which is also the direction of subsequent in-depth research in this paper.

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References

1. Le, T.T.; Ikram, M. Do sustainability innovation and firm competitiveness help improve firm performance? Evidence from the SME sector in vietnam. *Sustain. Prod. Consum.* **2022**, *29*, 588–599. [CrossRef]
2. Xue, Y.; Jiang, C.; Guo, Y.; Liu, J.; Wu, H.; Hao, Y. Corporate social responsibility and high-quality development: Do green innovation, environmental investment and corporate governance matter? *Emerg. Mark. Financ. Trade* **2022**, *58*, 3191–3214. [CrossRef]
3. Fang, Z.; Razzaq, A.; Mohsin, M.; Irfan, M. Spatial spillovers and threshold effects of internet development and entrepreneurship on green innovation efficiency in China. *Technol. Soc.* **2022**, *68*, 101844. [CrossRef]
4. Loučanová, E.; Olšiaková, M.; Štofková, J. Ecological Innovation: Sustainable Development in Slovakia. *Sustainability* **2022**, *14*, 12620. [CrossRef]
5. Lingyan, M.; Zhao, Z.; Malik, H.A.; Razzaq, A.; An, H.; Hassan, M. Asymmetric impact of fiscal decentralization and environmental innovation on carbon emissions: Evidence from highly decentralized countries. *Energy Environ.* **2022**, *33*, 752–782. [CrossRef]
6. Iqbal, Q.; Piwowar-Sulej, K. Sustainable leadership in higher education institutions: Social innovation as a mechanism. *Int. J. Sustain. High. Educ.* **2022**, *23*, 1–20. [CrossRef]
7. Iqbal, Q.; Piwowar-Sulej, K. Sustainable leadership and heterogeneous knowledge sharing: The model for frugal innovation. *Eur. J. Innov. Manag.* **2023**. *ahead-of-print*. . [CrossRef]
8. Hao, Z.; Zhang, X.; Wei, J. Research on the effect of enterprise financial flexibility on sustainable innovation. *J. Innov. Knowl.* **2022**, *7*, 100184. [CrossRef]
9. Mingaleva, Z.; Shironina, E.; Lobova, E.; Olenev, V.; Plyusnina, L.; Oborina, A. Organizational culture management as an element of innovative and sustainable development of enterprises. *Sustainability* **2022**, *14*, 6289. [CrossRef]
10. Yang, G.; Liu, J.; Lian, P.; Rui, M. Tax incentives R&D manipulation and R&D performance. *Econ. Res.* **2017**, *52*, 110–124.
11. Cumming, D.; Ji, S.; Peter, R.; Tarsalewska, M. Market manipulation and innovation. *J. Bank. Financ.* **2020**, *120*, 105957. [CrossRef]
12. Lin, F.; Lin, S.W.; Fang, W.C. How CEO narcissism affects earnings management behaviors. *N. Am. J. Econ. Financ.* **2020**, *51*, 101080. [CrossRef]
13. Xiang, E.; Gasbarro, D.; Cullen, G.; Ruan, W. Does R&D expenditure volatility affect stock return? *J. Contemp. Account. Econ.* **2020**, *16*, 100211.

14. Lakhal, N.; Dedaj, B. R&D disclosures and earnings management: The moderating effects of IFRS and the global financial crisis. *J. Financ. Report. Account.* **2020**, *18*, 111–130.
15. Chen, Z.; Liu, Z.; Suárez Serrato, J.C.; Xu, D.Y. Notching R&D investment with corporate income tax cuts in China. *Am. Econ. Rev.* **2021**, *111*, 2065–2100.
16. Santoleri, P.; Mina, A.; Di Minin, A.; Martelli, I. The causal effects of R&D grants: Evidence from a regression discontinuity. *Rev. Econ. Stat.* **2022**, *7*, 1–42 .
17. Li, J.; Ren, H. Research and Development Manipulation,"Multi-Min Dilemma", and Effective Regulation: Stochastic Evolutionary Game Model and Simulation. *J. Syst. Manag.* **2020**, *29*, 1078.
18. Klimas, P.; Czakon, W. Gaming innovation ecosystem: Actors, roles and co-innovation processes. *Rev. Manag. Sci.* **2022**, *16*, 2213–2259. [CrossRef]
19. Luo, J.; Hu, M.; Huang, M.; Bai, Y. How does innovation consortium promote low-carbon agricultural technology innovation: An evolutionary game analysis. *J. Clean. Prod.* **2023**, *384*, 135564. [CrossRef]
20. Zhou, X.; Jia, M.; Wang, L.; Sharma, G.D.; Zhao, X.; Ma, X. Modelling and simulation of a four-group evolutionary game model for green innovation stakeholders: Contextual evidence in lens of sustainable development. *Renew. Energy* **2022**, *197*, 500–517. [CrossRef]
21. Zhang, S.; Yu, Y.; Zhu, Q.; Qiu, C.M.; Tian, A. Green innovation mode under carbon tax and innovation subsidy: An evolutionary game analysis for portfolio policies. *Sustainability* **2020**, *12*, 1385. [CrossRef]
22. Li, J.; Ren, H.; Zhang, C.; Li, Q.; Duan, K. Substantive innovation or strategic innovation? Research on multiplayer stochastic evolutionary game model and simulation. *Complexity* **2020**, *2020*, 1–15. [CrossRef]
23. Liu, H.; Xing, F.; Li, B.; Yakshtas, K. Does the high-tech enterprise certification policy promote innovation in China? *Sci. Public Policy* **2020**, *47*, 678–688. [CrossRef]
24. Xu, K.; Geng, C.; Wei, X.; Jiang, H. Financing development, financing constraint and R&D investment of strategic emerging industries in China . *J. Bus. Econ. Manag.* **2020**, *21*, 1010–1034.
25. Tian, B.; Yu, B.; Chen, S.; Ye, J. Tax incentive, R&D investment and firm innovation: Evidence from China. *J. Asian Econ.* **2020**, *71*, 101245.
26. Gregova, E.; Smrcka, L.; Michalkova, L.; Svabova, L. Impact of tax benefits and earnings management on capital structures across V4 countries. *Acta Polytech. Hung.* **2021**, *18*, 221–244. [CrossRef]
27. Aghion, P.; Howitt, P. A model of Growth through Creative Destruction. *Econometrica* **1992**, *60*, 323-351. [CrossRef]
28. Romer, P.M. Endogenous technological change. *J. Political Econ.* **1990**, *98*, S71–S102. [CrossRef]
29. Hasan, I.; Tucci, C.L. The innovation–economic growth nexus: Global evidence. *Res. Policy* **2010**, *39*, 1264–1276. [CrossRef]
30. Verspagen, B. 487 Innovation and Economic Growth. In *The Oxford Handbook of Innovation*; Oxford University Press: Oxford, UK, 2006.
31. Li, Y.; Solaymani, S. Energy consumption, technology innovation and economic growth nexuses in Malaysian. *Energy* **2021**, *232*, 121040. [CrossRef]
32. Stoica, O.; Roman, A.; Rusu, V.D. The nexus between entrepreneurship and economic growth: A comparative analysis on groups of countries. *Sustainability* **2020**, *12*, 1186. [CrossRef]
33. Williams, B. The Rate and Direction of Inventive Activity: Economic and Social Factors. *Econ. J.* **1963**, *73*, 312–315 . [CrossRef]
34. Roper, S.; Vahter, P.; Love, J.H. Externalities of openness in innovation. *Res. Policy* **2013**, *42*, 1544–1554. [CrossRef]
35. Roper, S.; Love, J.H.; Bonner, K. Firms' knowledge search and local knowledge externalities in innovation performance. *Res. Policy* **2017**, *46*, 43–56. [CrossRef]
36. Aldieri, L.; Carlucci, F.; Vinci, C.P.; Yigitcanlar, T. Environmental innovation, knowledge spillovers and policy implications: A systematic review of the economic effects literature. *J. Clean. Prod.* **2019**, *239*, 118051. [CrossRef]
37. Hájek, P.; Stejskal, J. R&D cooperation and knowledge spillover effects for sustainable business innovation in the chemical industry. *Sustainability* **2018**, *10*, 1064.
38. Bronzini, R.; Iachini, E. Are incentives for R&D effective? Evidence from a regression discontinuity approach. *Am. Econ. J. Econ. Policy* **2014**, *6*, 100–134.
39. Edler, J.; Fagerberg, J. Innovation policy: What, why, and how. *Oxf. Rev. Econ. Policy* **2017**, *33*, 2–23. [CrossRef]
40. Akcigit, U.; Hanley, D.; Serrano-Velarde, N. Back to basics: Basic research spillovers, innovation policy, and growth. *Rev. Econ. Stud.* **2021**, *88*, 1–43. [CrossRef]
41. Li, W.; Zheng, M. Is it substantive innovation or strategic innovation?—Impact of macroeconomic policies on micro-enterprises' innovation. *Econ. Res. J.* **2016**, *4*, 60–73.
42. Lian, G.; Xu, A.; Zhu, Y. Substantive green innovation or symbolic green innovation? The impact of ER on enterprise green innovation based on the dual moderating effects. *J. Innov. Knowl.* **2022**, *7*, 100203. [CrossRef]
43. Zhang, M.; Huang, M. Study on the impact of informal environmental regulation on substantive green innovation in China: Evidence from PITI disclosure. *Environ. Sci. Pollut. Res.* **2023**, *30*, 10444–10456. [CrossRef]
44. Liu, S.; Du, J.; Zhang, W.; Tian, X.; Kou, G. Innovation quantity or quality? The role of political connections. *Emerg. Mark. Rev.* **2021**, *48*, 100819. [CrossRef]
45. Wan, Y.; Xu, Y. High-tech identification policy, R&D manipulation and firm technological innovation efficiency. *Sci. Res. Manag.* **2019**, *40*, 54.

46. Wan, Y.; Xu, Y.; Xu, W. Additional deduction policy, R&D manipulation and independent innovation of private firms. *Sci. Res. Manag.* **2020**, *41*, 83.
47. Lei, G.; Guo, Y. Does the High-Tech Enterprise Identity Policy Promote Innovation. *Evid. List. Co. China* **2018**, *9*, 32–47.
48. Jiang, J.; Su, P.; Ge, Z. The high-and new-technology enterprise identification, marketization process and the total factor productivity of enterprise. *Kybernetes* **2021**, *50*, 528–549. [CrossRef]
49. Dai, X.; Wang, F. Does the high-and new-technology enterprise program promote innovative performance? Evidence from Chinese firms. *China Econ. Rev.* **2019**, *57*, 101330. [CrossRef]
50. Bai, M.; Li, S.; Lien, D.; Yu, C.F.J. The winner's curse in high-tech enterprise certification: Evidence from stock price crash risk. *Int. Rev. Financ. Anal.* **2022**, *82*, 102175. [CrossRef]
51. Yang, G.; Rui, M. The incentive effect and catering effect of tax-reducing policy for high-tech enterprises. *Econ. Res. J.* **2020**, *9*, 174–190.
52. Zhang, W.; Hu, P.; Wang, J.J.; Li, Z.; Zheng, H.; Gao, X. Equity incentive plans and R&D investment manipulation: Evidence from China. *Account. Financ.* **2022**, *62*, 4157–4183.
53. Ding, X.; Yang, X.; Xu, L. International Board of Directors, R&D Manipulation and Innovation Performance. *Collect. Essays Financ. Econ.* **2020**, *259*, 94.
54. Shen, Y.; Ruan, Q. Accounting Conservatism, R&D Manipulation, and Corporate Innovation: Evidence from China. *Sustainability* **2022**, *14*, 9048.
55. Xiong, R.; Wei, P.; Yang, J.; Cristofini, L.A. Tax incentive, R&D manipulation and enterprises' innovation performance: The moderating role of political connections. *Int. J. Technol. Manag.* **2023**, *91*, 264–285.
56. Yao, Y.; Xue, S.; Sun, T. Do comment letters from the stock exchanges have governance effect on R&D manipulation? *China J. Account. Stud.* **2020**, *8*, 528–555.
57. Liu, D.; Wang, L.; Yan, J.; Wan, H. R&D manipulation and SEO pricing in the Chinese capital market: The information effect of inefficient investment. *Res. Int. Bus. Financ.* **2023**, *65* , 101946.
58. He, Y.; Zhang, X.; Hao, P.; Dai, X. A new broom sweeps clean: Evidence of the inhibiting effects of returnee managers on R&D manipulation. *Innovation* **2020**, *22*, 290–315.
59. Yuan, Z.; Wang, P.; Fu, Y. Has the academic experience of executives affected the R&D manipulation of enterprises? *Foreign Econ. Manag.* **2020**, *42*, 109–122.
60. Li, J.; Ren, H.; Zhen, J. Stochastic evolutionary game analysis of multiple supervision paths of enterprise R&D manipulation. *Chin. J. Manag. Sci.* **2019**, *25*, 1–15.
61. Zhou, L.A. Governing China's local officials: An analysis of promotion tournament model. *Econ. Res. J.* **2007**, *7*, 36–50.
62. Wang, X.; Gu, C.; Zhao, J.; Quan, J. A review of stochastic evolution dynamics and its cooperative mechanism. *J. Syst. Sci. Math. Sci.* **2019**, *39*, 1533.