Mechanism of Government Subsidy–Driven Corporate Green Innovation from the Perspective of Multi-Actor Co-governance

Original Research Article

Abstract

Correcting market failures in green innovation requires coordinated efforts from the government, market, and society. Breaking through the limitation of analyzing a single policy instrument, this study follows a mixed research paradigm of "phenomenon observation – theoretical deduction – numerical simulation." Based on statistical analysis of data from Chinese A-share listed companies from 2008 to 2024, this paper constructs a tripartite evolutionary game model involving local governments, enterprises, and the public to explain the underlying dynamic game mechanisms. Parameters derived from statistical analysis are further used to support numerical simulations, aiming to reveal the dynamic mechanism through which fiscal subsidies drive corporate green innovation under multi-actor interaction.

The results show that: (1) government environmental subsidies are the core driving force that encourages enterprises to overcome the cost barrier of innovation, and the incentive effect is stronger for high-carbon enterprises; (2) subsidies are transformed into innovation outputs through the pathway of inducing R&D investment, with a significant mediating effect; and (3) environmental regulation intensity and market competition significantly positively moderate the effect of subsidies.

The conclusions indicate that constructing a composite governance system characterized by balanced rewards and punishments, market coordination, and social co-governance is key to improving subsidy efficiency and promoting the green transformation of enterprises.

Keywords: Government subsidies; Green innovation; Evolutionary game; Evolutionarily stable strategy; Simulation analysis

1 Introduction

Against the macro background of addressing global climate change and achieving China's dual-carbon strategic goals, promoting a comprehensive green transformation of economic and social development has become a distinctive theme of high-quality development in the new era. Enterprises, as the primary carriers of economic activities, are both the source of resource consumption and pollution emissions and the main actors of green technological innovation. Enhancing enterprises' capability for green technological innovation not only concerns their own sustainable development but also directly determines the success or failure of China's industrial structure adjustment and ecological civilization construction.

In fant green technological innovation possesses typical characteristics of ”dual externalities” (environmental spillovers and knowledge spillovers), high investment, long cycles, and high risk (Chen et al., 2024). These inherent attributes lead to severe market failures, causing enterprises that pursue profit maximization to lack intrinsic motivation to actively engage in high-risk green innovation activities. In addition, significant heterogeneity exists among enterprises in terms of whether they engage in green innovation and the level of innovation output. Many firms remain trapped in a low-end lock-in state. Therefore, government regulation becomes a necessary external force to correct market failures and internalize environmental costs.

In practice, fiscal subsidies and fiscal penalties are the most direct and commonly used combination of policy instruments for governments to intervene in corporate environmental behavior. Although existing literature has extensively explored the relationship between government regulation and corporate green innovation under the Porter hypothesis (Liang and Luo, 2023), there remains room for further expansion. On the one hand, some studies examine the implementation effect of a single policy tool only from a static perspective, ignoring the dynamic game and strategic interaction among multiple actors (such as government, enterprises, and the public) based on bounded rationality in the process of environmental governance. On the other hand, theoretical modeling and empirical testing are often separated, lacking systematic research that combines complex game mechanisms with large-sample micro-data (Zhang and Gao, 2025).

Therefore, this study follows the mixed research paradigm of “phenomenon observation – theoretical deduction – numerical simulation.” First, descriptive statistics based on micro-level data reveal the real differences in corporate green innovation behavior. On this basis, a tripartite evolutionary game model including local governments, enterprises, and the public is constructed. Simulation analysis based on statistically obtained parameters is then conducted. Through numerical simulation and sensitivity analysis, the study explores the dynamic mechanism and evolutionary path through which changes in fiscal subsidy intensity and penalty strength affect the equilibrium strategies of the game system.

This research aims to deepen the understanding of multi-actor environmental collaborative governance mechanisms from a dynamic evolutionary perspective, providing a theoretical basis and decision-making reference for governments to optimize differentiated subsidy policies and design scientific reward–punishment mechanisms.

2 Construction and Analysis of the Evolutionary Game Dynamic Model among Government, Enterprises, and the Public

2.1 Data Sources

This study takes Chinese A-share listed companies from 2008 to 2024 as the research sample. Data are obtained from the CSMAR database, Wind financial terminal, and the National Intellectual Property Administration patent database. After excluding financial firms, ST/*ST companies, and samples with missing key variables, and performing 1% winsorization on continuous variables, a final dataset of 6,746 unbalanced panel observations from 650 companies is obtained.

2.2 Descriptive Statistics

Overall, significant differences exist in green technological innovation among sample enterprises. The ratio of variance to mean reaches 63.4, revealing severe over-dispersion characteristics in the data. This indicates that a small number of enterprises contribute a large amount of patent output, while a considerable proportion of enterprises have low or even zero output.

The core explanatory variable (government environmental subsidies) and moderating variables (industry competition and environmental regulation intensity) also show large distribution spans and differences. The standard deviations of control variables are generally low, indicating that the sample firms are relatively concentrated and symmetric in basic characteristics such as size, financial structure, profitability, and age, and are generally in a stable and moderately growing state.

Table 1: Descriptive Statistics of Main Variables

Variable	N	Mean	Std. Dev.	Min	Median	Max
Total green patent applications (`patent_all`)	6746	23.355	38.471	0	11.000	611.000
Log environmental subsidies (`sub_env`)	6746	12.151	5.546	0	13.934	19.236
...	...	...	...	...	...	...
Industry competition (`hhi_inv`)	6746	8.421	4.240	3.861	7.351	22.874
Environmental regulation intensity (`er`)	6746	0.014	0.005	0.002	0.014	0.027

Note: N denotes the number of observations. Continuous variables are winsorized at the upper and lower 1%.

2.3 Construction and Analysis of the Evolutionary Game Model

2.3.1 Model Assumptions and Payoff Matrix Construction

Table 2: Parameter Description

Parameter	Symbol	Parameter	Symbol
Enterprise innovation revenue	R_1	Government reporting reward	A
Enterprise non-innovation revenue	R_2	Government regulatory cost	G
Basic innovation cost	C_0	Government comprehensive revenue	B
Basic R&D investment	C_T	Government credibility loss	L_g
Government subsidy	S	Environmental damage	D
Government fine	F	R&D promotion coefficient	β
Public reputation benefit	P_1	R&D efficiency coefficient	α
Public reputation loss	P_2	Market competition	M
Public supervision cost	C_p	Competition amplification coefficient	θ
Environmental improvement utility	U_1	Environmental regulation intensity	E
Environmental deterioration utility	U_2	Regulation amplification coefficient	φ

Assumption 1: Participants include government, enterprises, and the public, all of which are bounded rational actors. Their strategy selection probabilities are: government's strong regulation (x) or weak regulation ($1-x$); enterprises' low-carbon innovation (y) or no innovation ($1-y$); public's active supervision (z) or passive supervision ($1-z$), where $x, y, z \in [0, 1]$.

Assumption 2: Enterprises that innovate obtain direct benefits R_1 but must bear innovation costs C_0 (Wenwen et al., 2024). Under strong regulation, the government provides subsidies S (Chen et al., 2024) to innovative firms and imposes fines F on non-innovative firms.
Assumption 3: Active public supervision incurs costs C_p. When enterprises innovate, the public gains environmental utility U_1 and enterprises gain reputational benefits P_1; when enterprises do not innovate, the public obtains environmental utility U_2 ($U_1 > U_2$) and enterprises suffer reputational losses P_2. Under strong regulation, valid public reporting can receive rewards A (Wu et al., 2026).
Assumption 4: Strong regulation requires regulatory costs G and involves subsidies S, fines F, rewards A, and environmental damage handling D, but generates comprehensive benefits B. Weak regulation has no direct cost but results in credibility loss L_g and environmental damage D.
Assumption 5: Moderating mechanisms: market competition M (Wu et al., 2026) and environmental regulation intensity φ (Yanhong and Bohan, 2023) are introduced as moderating variables, both positively moderating the incentive effect of subsidies.
Based on the above assumptions, the following tripartite evolutionary game payoff matrix among the government, high-carbon enterprises, and the public is constructed.

Table 3: Tripartite Evolutionary Game Payoff Matrix

Enterprise strategy	Public strategy	Strong government regulation (x)	Weak government regulation ($1-x$)
Innovation (y)	Active supervision (z)	$\begin{pmatrix} R_1-(C_0-\alpha(C_T+\beta S))+S(1+\theta M+\varphi E)+P_1 \\ -C_p+U_1+A \\ B-G-S(1+\theta M+\varphi E)-A \end{pmatrix}$	$\begin{pmatrix} R_1-C_0+P_1 \\ -C_p+U_1 \\ -L_g \end{pmatrix}$
	Passive supervision ($1-z$)	$\begin{pmatrix} R_1-(C_0-\alpha(C_T+\beta S))+S(1+\theta M+\varphi E) \\ 0 \\ B-G-S(1+\theta M+\varphi E) \end{pmatrix}$	$\begin{pmatrix} R_1-C_0 \\ 0 \\ -L_g \end{pmatrix}$
Non-innovation ($1-y$)	Active supervision (z)	$\begin{pmatrix} R_2-F-P_2 \\ -C_p+U_2+A \\ B-G+F-A-D \end{pmatrix}$	$\begin{pmatrix} R_2-P_2 \\ -C_p+U_2 \\ -L_g-D \end{pmatrix}$
	Passive supervision ($1-z$)	$\begin{pmatrix} R_2-F \\ 0 \\ B-G+F-D \end{pmatrix}$	$\begin{pmatrix} R_2 \\ 0 \\ -L_g-D \end{pmatrix}$

2.3.2 Replicator Dynamic Analysis of the Government, High-Energy-Consuming Enterprises, and the Public

Based on the constructed tripartite payoff matrix, the replicator dynamic equations of local governments, high-energy-consuming enterprises, and the public are derived according to evolutionary game theory. The stability conditions and critical thresholds of their strategic choices are then solved. From the perspective of parameters, the micro-mechanisms of strategy evolution and the interdependence among the strategies of different actors are further revealed.
(1) Evolution of local government strategy.
Let the proportion of local governments choosing strong regulation be x, and the proportion choosing weak regulation be $1-x$. The expected payoffs of the two strategies are calculated as follows: The expected payoff of the local government choosing the "strong regulation" strategy E_{g1} is:

$$\begin{aligned} E_{g1} &= yz\left[B-G-S(1+\theta M+\varphi E)-A\right]+y(1-z)\left[B-G-S(1+\theta M+\varphi E)\right] \\ &\quad +(1-y)z(B-G+F-A-D)+(1-y)(1-z)(B-G+F-D), \end{aligned} \tag{2.1}$$

The expected payoff of the local government choosing the "weak regulation" strategy E_{g2} is:

$$E_{g2} = yz(-L_g)+y(1-z)(-L_g)+(1-y)z(-L_g-D)+(1-y)(1-z)(-L_g-D). \tag{2.2}$$

The average expected payoff of the local government $\bar{E}_g$ is:

$$\bar{E}_g = xE_{g1} + (1-x)E_{g2}. \tag{2.3}$$

According to the replicator dynamic principle, the growth rate of a strategy equals its relative fitness. Therefore, the replicator dynamic equation for the local government adopting the "strong regulation" strategy is:

$$F(x) = \frac{dx}{dt} = x(E_{g1} - \bar{E}_g) = x(1-x)(E_{g1} - E_{g2}). \tag{2.4}$$

Substituting and simplifying yields:

$$F(x) = x(x-1)\left[G - F - B - L_g + Fy + Sy + Az + ES\varphi y + MS\theta y\right]. \tag{2.5}$$

Let

$$G(y) = G - F - B - L_g + Fy + Sy + Az + ES\varphi y + MS\theta y, \tag{2.6}$$

then $F(x) = x(x-1)G(y)$ and

$$F'(x) = (2x-1)G(y). \tag{2.7}$$

The critical value of enterprise innovation proportion is:

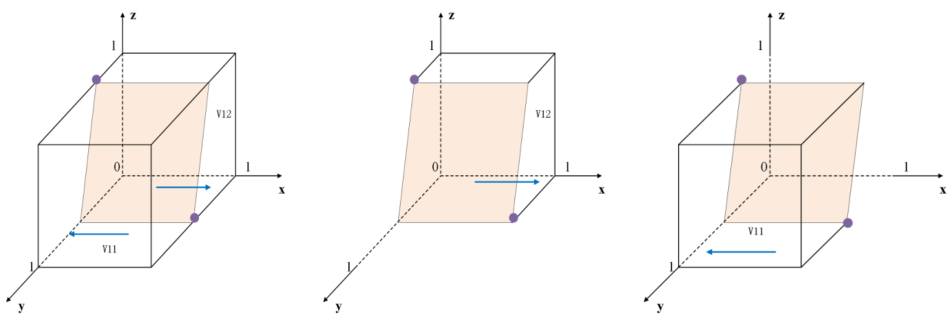
$$y^* = -\frac{G - F - B - L_g + Az}{F + S + ES\varphi + MS\theta}. \tag{2.8}$$

Accordingly, the evolutionarily stable strategy (ESS) of the local government can be analyzed as follows:

When $y = y^*$, $G(y) = 0$, $F(x) \equiv 0$, and all x are stable states.

When $y < y^*$, $G(y) < 0$. In this case, $F'(x)|_{x=0} < 0$ and $F'(x)|_{x=1} > 0$, thus $x = 0$ is the ESS. This indicates that when enterprises have insufficient willingness to innovate, the government tends to adopt weak regulation.

When $y > y^*$, $G(y) > 0$. In this case, $F'(x)|_{x=0} > 0$ and $F'(x)|_{x=1} < 0$, thus $x = 1$ is the ESS. This implies that when enterprise innovation becomes active, the government tends to adopt strong regulation.



$y = y^*$ $\quad$ $y < y^*$ $\quad$ $y > y^*$

Figure 1: Evolutionary Trend of Government Behavior

Conclusion 1 (Reaction Function of Government Regulation): The evolution of local government regulatory intensity exhibits a critical value y^* with respect to the enterprise innovation proportion y. The policy implication is that the denominator of the critical value, $F + S + ES\varphi + MS\theta > 0$, indicates that increasing fines (F), subsidies (S), environmental regulation intensity (E), or market competition (M) can reduce the value of y^*. This implies that a strong reward–penalty policy mix together with a sound market regulatory environment can lower the innovation threshold required for the government to adopt and maintain a strong regulation strategy. Consequently, even when fewer enterprises actively engage in innovation, the government still has incentives to maintain regulatory pressure, thereby exerting a disciplinary effect on lagging firms.

(2) Evolution of high-energy-consumption enterprise strategy.

Let the proportion of enterprises choosing low-carbon innovation be y, and the proportion choosing no innovation be $1-y$.

$$\begin{aligned} E_{e1} &= xz\left[R_1 - (C_0 - \alpha(C_T + \beta S)) + S(1+\theta M + \varphi E) + P_1\right] \\ &\quad + x(1-z)\left[R_1 - (C_0 - \alpha(C_T + \beta S)) + S(1+\theta M + \varphi E)\right] \\ &\quad + (1-x)z(R_1 - C_0 + P_1) + (1-x)(1-z)(R_1 - C_0), \end{aligned} \tag{2.9}$$

$$E_{e2} = xz(R_2 - F - P_2) + x(1-z)(R_2 - F) + (1-x)z(R_2 - P_2) + (1-x)(1-z)R_2. \tag{2.10}$$

The average expected payoff is $\bar{E}_e = yE_{e1} + (1-y)E_{e2}$. The replicator dynamic equation is:

$$F(y) = \frac{dy}{dt} = y(E_{e1} - \bar{E}_e) = y(1-y)(E_{e1} - E_{e2}). \tag{2.11}$$

After simplification:

$$\begin{aligned} F(y) = y(1-y)\Big[&R_1 - C_0 - R_2 + Fx + P_1 z + P_2 z + Sx + C_T\alpha x \\ &+ ES\varphi x + MS\theta x + S\alpha\beta x\Big]. \end{aligned} \tag{2.12}$$

Let

$$H(z) = R_1 - C_0 - R_2 + Fx + P_1 z + P_2 z + Sx + C_T\alpha x + ES\varphi x + MS\theta x + S\alpha\beta x, \tag{2.13}$$

then $F(y) = y(1-y)H(z)$ and

$$F'(y) = (1-2y)H(z). \tag{2.14}$$

The critical value of public supervision proportion is:

$$z^* = -\frac{R_1 - C_0 - R_2 + Fx + Sx + C_T\alpha x + ES\varphi x + MS\theta x + S\alpha\beta x}{P_1 + P_2}. \tag{2.15}$$

When $z = z^*$, all y are stationary. When $z < z^*$, $y = 0$ is the ESS (no innovation). When $z > z^*$, $y = 1$ is the ESS (innovation).

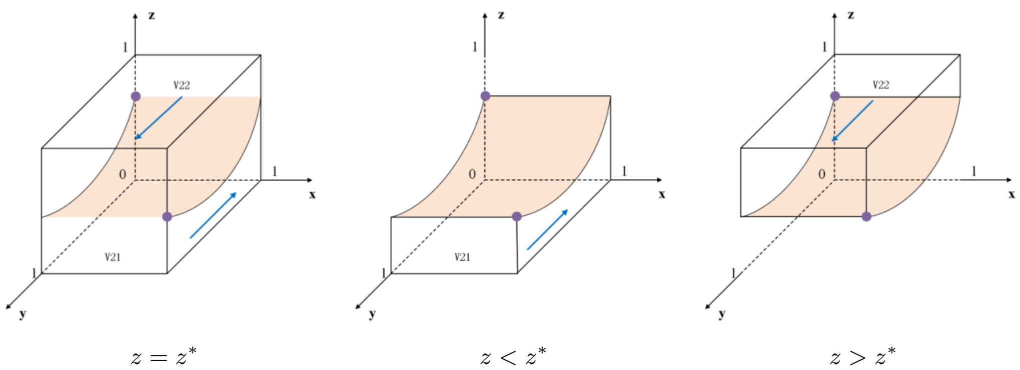


Figure 2: Evolutionary Trend of Enterprise Behavior

Conclusion 2 (Decision function of enterprise innovation). The evolution of innovation willingness among high-energy-consuming enterprises exhibits a critical value z^* with respect to public supervision proportion z. Strengthening reputational gains (P_1) and losses (P_2), together with government subsidies (S) and fines (F), can lower the critical threshold and promote innovation.

(3) Evolutionary analysis of public strategies.

Let the proportion of the public choosing active supervision be z, and the proportion choosing passive supervision be $1-z$.

$$E_{p1} = xy(-C_p+U_1+A)+x(1-y)(-C_p+U_2+A)+(1-x)y(-C_p+U_1)+(1-x)(1-y)(-C_p+U_2). \tag{2.16}$$

The expected payoff of passive supervision is $E_{p2} = 0$, and the average expected payoff is $\bar{E}_p = zE_{p1}$. The replicator dynamic equation is:

$$F(z) = \frac{dz}{dt} = z(E_{p1} - \bar{E}_p) = z(1-z)E_{p1} = z(1-z)(U_2 - C_p + Ax + U_1 y - U_2 y). \tag{2.17}$$

Let $K(x) = U_2 - C_p + Ax + U_1 y - U_2 y$, then $F(z) = z(1-z)K(x)$ and

$$F'(z) = (1-2z)K(x). \tag{2.18}$$

The critical value of strong regulation proportion is:

$$x^* = -\frac{U_2 - C_p + (U_1 - U_2)y}{A}. \tag{2.19}$$

When $x = x^*$, all z are stationary. When $x < x^*$, $z = 0$ is the ESS (free-riding). When $x > x^*$, $z = 1$ is the ESS (active supervision).

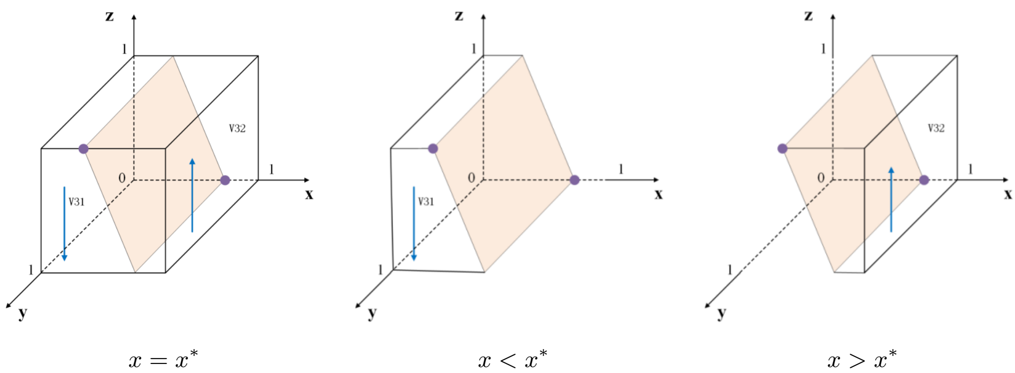


Figure 3: Evolutionary Trend of Public Behavior

Conclusion 3 (Participation function of public supervision).The evolution of the public's willingness to supervise exhibits a critical value x^* with respect to government regulatory intensity x. Establishing and effectively implementing reporting rewards (A), reducing supervision cost (C_p), and improving environmental utility differences ($U_1 - U_2$) can significantly lower this critical threshold and strengthen social co-governance.

2.3.3 System Equilibrium and Stability Analysis

After separately analyzing the replicator dynamic processes of the three actors, this study further investigates the equilibrium states and stability of the entire game system composed of local governments, high-energy-consuming enterprises, and the public.

(1) Solving the equilibrium points and constructing the Jacobian matrix.
From $F(x) = 0$, $F(y) = 0$, and $F(z) = 0$, the equilibrium points are:

$$O(0,0,0),\ A(0,0,1),\ B(0,1,0),\ C(0,1,1),\ D(1,0,0),\ E(1,0,1),\ F(1,1,0),\ G(1,1,1).$$

The Jacobian matrix of the tripartite evolutionary game system is:

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}. \tag{2.20}$$

Substituting the partial derivatives obtained above into the expression yields the complete Jacobian matrix.According to the Lyapunov indirect method, if all eigenvalues corresponding to an equilibrium point have negative real parts, the point is a locally asymptotically stable ESS.

Table 4: Eigenvalues of the Evolutionary Game Model

Equilibrium point	λ_1	λ_2	λ_3
$O(0,0,0)$	$B+F-G+L_g$	$R_1-C_0-R_2$	U_2-C_p
$A(0,0,1)$	$B+F-G+L_g-A$	$P_1+P_2+R_1-C_0-R_2$	C_p-U_2
$B(0,1,0)$	$B-G+L_g-S-ES\varphi-MS\theta$	$C_0-R_1+R_2$	U_1-C_p
$C(0,1,1)$	$B-G+L_g-A-S-ES\varphi-MS\theta$	$C_0-P_1-P_2-R_1+R_2$	C_p-U_1
$D(1,0,0)$	$G-F-B-L_g$	$F-C_0+R_1-R_2+S+C_T\alpha+ES\varphi+MS\theta+S\alpha\beta$	$A+U_2-C_p$
$E(1,0,1)$	$G-F-B-L_g+A$	$P_1+P_2+F-C_0+R_1-R_2+S+C_T\alpha+ES\varphi+MS\theta+S\alpha\beta$	C_p-A-U_2
$F(1,1,0)$	$G-B-L_g+S+ES\varphi+MS\theta$	$C_0-F-R_1+R_2-S-C_T\alpha-ES\varphi-MS\theta-S\alpha\beta$	$A+U_1-C_p$
$G(1,1,1)$	$G-B-L_g+A+S+ES\varphi+MS\theta$	$C_0-P_1-P_2-F-R_1+R_2-S-C_T\alpha-ES\varphi-MS\theta-S\alpha\beta$	C_p-A-U_1

(2) Stability conditions and policy implications of key equilibrium points.
This section focuses on the conditions under which the ideal collaborative state $G(1,1,1)$ and the governance failure state $O(0,0,0)$ become ESS.
Stability conditions of the ideal collaborative equilibrium point $G(1,1,1)$.For this point to become ESS, the following conditions should hold:

$$G + A + S(1 + \varphi E + \theta M) < B + L_g, \tag{2.21}$$

$$C_0 + R_2 < R_1 + F + P_1 + P_2 + S\left(1 + \frac{\alpha C_T}{S} + \varphi E + \theta M + \alpha\beta\right), \tag{2.22}$$

$$C_p < A + U_1. \tag{2.23}$$

These inequalities imply that policy costs should be lower than governance benefits for governments, innovation returns should exceed innovation barriers for enterprises, and supervision costs should be lower than social and policy returns for the public.
Stability conditions of the governance failure equilibrium point $O(0,0,0)$.If $B + F + L_g < G$, $R_1 < C_0 + R_2$, and $U_2 < C_p$, the system converges to governance failure. This means excessively high regulatory costs combined with weak subsidy and penalty intensities cannot overcome enterprise innovation barriers and cannot sustain public supervision incentives.
In summary, the stability analysis not only derives mathematically the possible final states of system evolution and their conditions, but also reveals the complex coupling relationship between regulation, market, and subsidy instruments and the strategic responses of multiple actors.

2.3.4 Numerical Analysis of the Evolutionary Game under the Tripartite Game

Based on the above statistical analysis and evolutionary game analysis, simulation parameters are set as follows:

$$R_1 = 7.5,\ R_2 = 0.89,\ C_0 = 16,\ C_T = 18.9,\ S = 1.8,\ F = 4,\ P_1 = 1.5,\ P_2 = 2.5,$$
$$C_p = 1,\ U_1 = 2.5,\ U_2 = 1,\ G = 2.5,\ A = 1,\ B = 6,\ L_g = 3,\ D = 4,$$
$$\beta = 0.16,\ \alpha = 0.12,\ M = 8.4,\ \theta = 0.0034,\ E = 0.014,\ \varphi = 3.28.$$

(1) Impact of government subsidy intensity (S) on strategy evolution.
Environmental subsidies are a core policy instrument through which the government corrects positive externalities and incentivizes enterprise low-carbon R&D (Yanhong and Bohan, 2023). To examine the impact of support levels, numerical simulations are conducted with different subsidy intensities while keeping other parameters constant. The results show that low subsidy intensity leads to governance failure, moderate subsidy intensity promotes convergence to innovation-oriented equilibrium, and excessively high subsidy intensity may induce strategic oscillation between government and enterprises (Yang and Xie, 2023). Therefore, the government subsidy intensity (S) exhibits a clear "leverage effect." Low levels of subsidies fail to induce innovation, while excessively high subsidies, although capable of accelerating transformation, may impose a heavy fiscal burden on local governments.

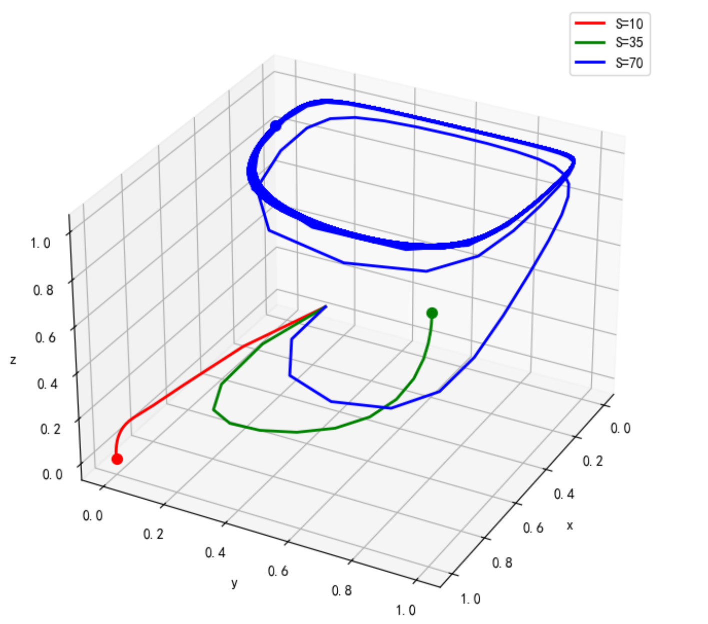


Figure 4: Strategy Space Trajectories of the Three Parties under Different Government Subsidy Intensities S

(2) Impact of government penalty intensity (F) on strategy evolution.
Government fines are a key negative incentive mechanism used to correct enterprise pollution behavior and increase the cost of violations. Numerical simulations are conducted with different penalty intensities while keeping other parameters constant. The results indicate that low penalties fail to exert substantial deterrence, while sufficiently high penalties can promote convergence toward a favorable equilibrium through stronger deterrence effects (Wu et al., 2025). Therefore, an appropriate level of penalty intensity is a necessary guarantee for the government to guide enterprise innovation. Only when exceeds a certain critical threshold can environmental regulation effectively exert its "pulling force," prompting enterprises to shift from end-of-pipe treatment toward source-oriented innovation.

Moderately increasing the cost of violations can also enhance enterprises' sensitivity to fiscal subsidies, compelling them to accelerate green patent output under the combined influence of external regulatory pressure and internal incentive forces.

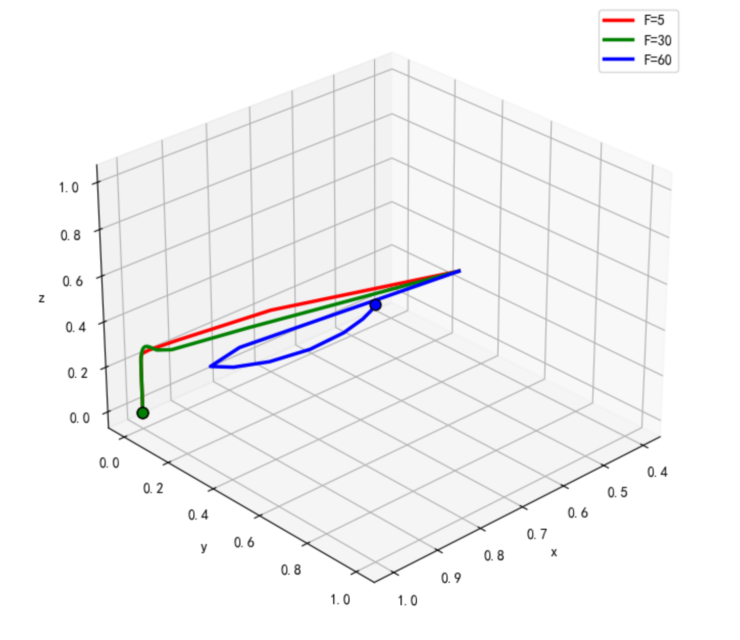


Figure 5: Strategy Space Trajectories of the Three Parties under Different Penalty Intensities F

6 Conclusion

Based on the Chinese institutional context, this paper opens the government environmental policy toolbox by constructing a tripartite evolutionary game model and conducting simulation analysis using micro-enterprise data. The study systematically evaluates the effect and mechanism of environmental subsidies on corporate low-carbon technological innovation.

Theoretical modeling and empirical results mutually support each other. Government environmental subsidies serve as the core engine driving enterprises to overcome the cost barrier of low-carbon innovation, while R&D investment acts as the key transmission channel through which subsidies are converted into substantive innovation outcomes. The synergistic interaction of regulation, market mechanisms, and subsidies constitutes the guarantee for achieving optimal governance outcomes.

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Competing Interests

Authors have declared that no competing interests exist.

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