

# The Impact of the Synergy between the Carbon Market and Green Credit on Green Innovation in Steel Enterprises

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## Abstract

Under the "Dual Carbon" goals, this paper examines the synergy between green credit and carbon markets in driving the steel industry's green transition. Using a tripartite evolutionary game model (government, banks, enterprises) and numerical simulations, we find that carbon price is the core driver, with effects varying non-linearly: low prices require strong government intervention; medium prices benefit from complementary low-interest financing; and high prices make green innovation an economic necessity, reducing policy marginal utility. We recommend establishing a rising carbon price mechanism, strengthening early-stage financial guidance, and shifting towards institutional optimization as the market matures.

## Keywords

Steel Industry; Green Transition; Green Credit; Carbon Trading Market; Evolutionary Game; Synergistic Mechanism.

## 1. Introduction

As the world's second-largest economy, China plays a pivotal role in promoting global green transition and is actively addressing current ecological and environmental challenges. To more effectively tackle the climate crisis, the country has placed the realization of the "Dual Carbon" goals—peaking carbon emissions by 2030 and achieving carbon neutrality by 2060—at the core of comprehensive green economic and social transformation in its new "15th Five-Year Plan," launching systematic top-level design and strategic deployment. The "15th Five-Year Plan" period marks the first five-year plan for the full implementation of the "dual control" system for total carbon emissions and intensity. Its core task is to ensure the timely achievement of the 2030 carbon peak goal, laying a solid foundation for carbon neutrality by 2060.

As the world's largest steel producer, China occupies a decisive position in the global steel industry, and its development trends profoundly influence the global industry landscape. Since 2000, accompanied by rapid economic growth, China's steel industry has achieved remarkable results: crude steel production was 128.5 million tons in that year; by the end of 2024, production reached 1.03 billion tons, accounting for 54.0% of global total production. However, alongside rapid industry expansion, severe environmental pressures have emerged. Data shows that in 2024, carbon emissions from China's steel industry reached 1.8 billion tons, accounting for approximately 50% of total global steel industry carbon emissions, representing the largest share among the 31 categories of China's manufacturing sector, and about 15% of the nation's total carbon emissions. This high-emission status highlights the urgency of green transition in the steel industry.

In the development of the green finance system, green credit is China's most mature and policy-complete tool, widely applied to promote green transition. On one hand, green credit guides enterprises to improve resource utilization efficiency, practice green production, and incorporate environmental performance into operational decisions through capital constraints or incentive mechanisms, thereby reversing traditional high-pollution, low-efficiency

production models. On the other hand, banks and other financial institutions are encouraged to take proactive initiatives, increasing support for sustainable industries such as energy conservation, environmental protection, and eco-friendly sectors, using financial means to aid ecological improvement, which in turn feeds back into the high-quality development of the financial sector through a sound ecological environment.

The Carbon Emission Trading Market (hereinafter referred to as the "Carbon Market") is a key policy tool for countries to control greenhouse gas emissions, address climate change, and promote green development. Currently, several major economies, including the EU, the US, Australia, and China, have established carbon markets. China launched seven local carbon market pilots successively starting in 2013 and officially started the national carbon emission trading market in July 2021, breaking through with the power generation sector, initially covering about 2,200 key emission units. On May 1, 2024, the "Interim Regulations on the Management of Carbon Emission Trading" came into effect. On March 26, 2025, the Ministry of Ecology and Environment released the "Work Plan for Expanding the Coverage of the National Carbon Emission Trading Market to Include the Steel, Cement, and Aluminum Smelting Industries," marking the first substantive expansion of industry coverage in the national carbon market, with industries like steel soon to be included in the trading system.

Research on game theory regarding green technology innovation has continuously extended the subjects involved in games to promote corporate green behavior. Foreign scholars have further studied the quality and efficiency of incentives and regulation. Zhou et al. established an evolutionary game model among the government, the public, polluting enterprises, and non-polluting enterprises within an environmental regulation framework, analyzing the differences in environmental contributions and heterogeneity in innovation-driven approaches between the two types of enterprises. They provided suggestions on how to promote the coordinated driving of corporate green innovation development and the coordinated relationship with environmental sustainability from the perspectives of environmental regulation and collaborative innovation [1]. Li and Gao took two types of manufacturing enterprises with different green R&D capabilities and banks as the subjects of an evolutionary game, examining the strategy choices of various subjects and key influencing factors under different environmental regulation policies [2]. Xu et al. established a tripartite game model involving the government, environmental service companies, and pollutant-discharging enterprises, further exploring how to effectively control illegal behaviors by environmental service companies and pollutant-discharging enterprises, and proposing corresponding countermeasures and suggestions for the government to improve regulatory effectiveness [3]. Chu et al. established a tripartite evolutionary game model involving local governments, polluting enterprises, and the public, arguing that public supervision and action can help alleviate the regulatory burden on local governments and coordinate with relevant government policies to improve the effectiveness of environmental regulation [4]. In the steel industry, Tian et al. (2024) [5] distinguished behavioral differences between large and small-to-medium-sized steel enterprises, constructing a tripartite evolutionary game model. Their research indicates that large enterprises are more sensitive to CBAM policies, while SMEs are more susceptible to free-riding behaviors. They also pointed out that government intervention needs to maintain moderate boundaries, as excessive intervention may lead to strategic oscillation, providing strategic guidance for the steel industry to cope with CBAM. Tang et al. (2025) [6] further constructed a bilateral evolutionary game model between the government and steel enterprises, finding that stable equilibrium is difficult to achieve without third-party supervision. They subsequently introduced a third-party regulatory body to form a tripartite game framework, emphasizing the importance of regulatory supervision for the stability of low-carbon strategies.

Based on the above background, this paper focuses on the impact of the synergy between green credit policies and the carbon market on the green innovation behavior of steel enterprises. It constructs a tripartite evolutionary game model involving the government, financial institutions, and steel enterprises to analyze the evolutionary stability of strategy choices by all parties. It explores how key factors influence the decision-making behaviors of each subject, thereby revealing multi-party strategy interaction mechanisms and their dynamic evolution paths that are closer to reality.

## 2. Tripartite Evolutionary Game Model for Green Transition of Steel Enterprises

To construct the game model, analyze the stability of strategies and equilibrium points for all parties, and examine the influence relationships of various elements, the following assumptions are made:

Assumption 1: This model involves three types of participants: {Government, Bank, Steel Enterprise}. The government's strategy space is {Incentive, No Incentive}, with the probability of adopting the "Incentive" strategy being  $x(0 \leq x \leq 1)$  and the probability of adopting the "No Incentive" strategy being  $1-x$ . The bank's strategy space is {Green Credit, Non-Green Credit}, with the probability of adopting the "Green Credit" strategy being  $y(0 \leq y \leq 1)$  and the probability of adopting the "Non-Green Credit" strategy being  $1-y$ . The steel enterprise's strategy space is {Green Innovation, Non-Green Innovation}, with the probability of adopting the "Green Innovation" strategy being  $z(0 \leq z \leq 1)$  and the probability of adopting the "Non-Green Innovation" strategy being  $1-z$ .

Assumption 2: When the government adopts an incentive policy, it needs to invest regulatory cost  $C_1$  to regulate banks and enterprises. It provides an interest subsidy at rate  $r$  to banks implementing green credit and imposes a loan penalty  $p$  on banks implementing traditional credit. It provides a subsidy  $S$  for the green project costs of steel enterprises implementing green transition and imposes a fine  $F$  on steel enterprises that do not undergo green transition. Corporate green innovation brings social benefits  $E$ , which can enhance the government's reputation, and the government can also receive transfer payments  $N_1$  from the central government. When the local government adopts a no-incentive strategy, it will not take any measures against banks and steel enterprises, but the government will be subject to administrative penalties  $N_2$ .

Assumption 3: The benchmark yield rates for commercial banks implementing green credit and traditional credit are  $i_g$  and  $i_n(i_g < i_n)$ , respectively.

Assumption 4: Steel enterprises reduce carbon emissions by increasing the proportion of electric arc furnace (EAF) steel. The steel price is  $P_1$ . The production volume of the steel enterprise during traditional production is  $Q_1$ , and the EAF steel production volume after green transition is  $Q_2$ . The replacement ratio between the newly added EAF steel production and converter steel production is  $n$ . The per-ton production cost of converter steel for the steel enterprise is  $C_2$ , and the per-ton production cost of EAF steel is  $C_3$ . When the steel enterprise undergoes green transition, the green project cost is  $C_4$ . The per-ton carbon emission of converter steel is  $T_1$ , and the per-ton carbon emission of EAF steel is  $T_2$ . To incentivize green transition and reduce the initial pressure on steel enterprises, the government grants enterprises a certain amount of free carbon quotas  $T_0$ . Through green transition, the enterprise fulfills part of its carbon quota obligations, and the remaining surplus quotas can be sold in the carbon market at carbon price  $P_2$  to generate revenue. If the enterprise does not undergo green transition and its carbon emissions fail to meet compliance standards, it must purchase quotas from the carbon market at price  $P_2$  for compliance.

Model parameters and their meanings are shown in Table 1.

**Table 1.** Model Parameters and Meanings

Parameter	Meaning
r	Interest subsidy rate by the government for banks implementing green credit
S	Subsidy given by the government for corporate green transition projects
E	Social benefits brought by corporate green innovation
$i_g$	Green credit interest rate
$i_n$	Traditional credit interest rate
$Q_1$	Steel production volume during traditional production
$Q_2$	EAF steel production volume after green transition
p	Penalty by the government on commercial banks for not formulating green credit policies
F	Penalty by the government on steel enterprises for not undergoing green transition
$C_1$	Cost of government regulation
$C_2$	Per-ton production cost of converter steelmaking
$C_3$	Per-ton production cost of EAF steelmaking
$P_1$	Steel price
$N_1$	Transfer payment from the central government to local governments for active regulation
$N_2$	Penalty from the central government to local governments for inactive regulation
$C_4$	Green project cost for steel enterprises
n	Capacity replacement ratio
$P_2$	Carbon price
$T_0$	Carbon quotas given by the government to steel enterprises
$T_1$	Per-ton carbon emission of converter steel
$T_2$	Per-ton carbon emission of EAF steel

**2.1. Construction and Analysis of Payoff Matrix**

**Table 2.** Government-Bank-Steel Enterprise Evolutionary Game Payoff Matrix

		Steel Enterprise	Government	
			Incentive x	No Incentive 1-x
Bank	Green Credit y	Green Innovation z	$E - rC_5 - S - C_1 + N_1;$ $(r + i_g)C_4;$ $S + P_1(Q_1 - (n - 1)Q_2) - i_gC_4 -$ $(C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 +$ $P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)$	$E - N_2;$ $i_gC_4;$ $P_1(Q_1 - (n - 1)Q_2) - i_gC_4 -$ $(C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 +$ $P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)$
		Non-Green Innovation 1-z	$F - C_1 + N_1;$ $0;$ $P_1Q_1 - C_2Q_1 - P_2(T_1Q_1 - T_0) -$ $F$	$-N_2;$ $0;$ $P_1Q_1 - C_2Q_1 - P_2(T_1Q_1 - T_0)$
	Non-Green Credit 1-y	Green Innovation z	$E - C_1 - S + p + N_1;$ $i_nC_4 - p;$ $S + P_1(Q_1 - (n - 1)Q_2) - i_nC_4 -$ $(C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 +$ $P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)$	$E - N_2;$ $i_nC_4;$ $P_1(Q_1 - (n - 1)Q_2) - i_nC_4 -$ $(C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 +$ $P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)$
		Non-Green Innovation 1-z	$F - C_1 + p + N_1;$ $-p;$ $P_1Q_1 - C_2Q_1 - F - P_2(T_1Q_1 -$ $T_0)$	$-N_2;$ $0;$ $P_1Q_1 - C_2Q_1 - P_2(T_1Q_1 - T_0)$

Based on the above assumptions, an evolutionary game payoff matrix with the Government-Bank-Steel Enterprise as strategy subjects is constructed, as shown in Table 2.

**2.1.1. Stability Analysis of Government Strategies**

Let  $U_{11}$  denote the expected return for the government choosing the "Regulate" (Incentive) strategy,  $U_{12}$  denote the expected return for choosing the "No Regulate" (No Incentive) strategy, and  $U_1$  denote the average return for the government, i.e.:

$$U_{11} = yz(E - rC_4 - S - C_1 + N_1) + y(1 - z)(F - C_1 + N_1) + (1 - y)z(E - C_1 - S + p + N_1) + (1 - y)(1 - z)(F - C_1 + p + N_1) \tag{1}$$

$$U_{12} = yz(E - N_2) + y(1 - z)(-N_2) + (1 - y)z(E - N_2) + (1 - y)(1 - z)(-N_2) \tag{2}$$

$$U_1 = xU_{11} + (1 - x)U_{12} \tag{3}$$

The government's replicator dynamic equation can be obtained:

$$F(x) = \frac{dx}{dt} = x(U_{11} - U_1) = x(1 - x)(F - C_1 + N_1 + N_2 + p - Fz - Sz - py - C_4ryz) \tag{4}$$

**2.1.2. Stability Analysis of Bank Strategies**

Let  $U_{21}$  denote the expected return for the bank choosing the "Green Credit" strategy,  $U_{22}$  denote the expected return for choosing the "Traditional Credit" strategy, and  $U_2$  denote the average return for the bank, i.e.:

$$U_{21} = xz((r + i_g)C_4) + (1 - x)z(i_gC_4) \tag{5}$$

$$U_{22} = xz(i_nC_4 - p) + (1 - x)z(i_nC_4) + x(1 - z)(-p) \tag{6}$$

$$U_2 = yU_{21} + (1 - y)U_{22} \tag{7}$$

The bank's replicator dynamic equation can be obtained:

$$F(y) = \frac{dy}{dt} = y(U_{21} - U_2) = y(1 - y)(px + C_4i_gz - C_4i_nz + C_4rxz) \tag{8}$$

**2.1.3. Stability Analysis of Steel Enterprise Strategies**

Let  $U_{31}$  denote the expected return for the enterprise choosing the "Green Innovation" strategy,  $U_{32}$  denote the expected re turn for choosing the "Non-Green Innovation" strategy, and  $U_3$  denote the average return for the enterprise, i.e.:

$$U_{31} = xy(S + P_1(Q_1 - (n - 1)Q_2) - i_gC_4 - (C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 + P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)) + x(1 - y)(S + P_1(Q_1 - (n - 1)Q_2) - i_nC_4 - (C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 + P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)) + (1 - x)y(P_1(Q_1 - (n - 1)Q_2) - i_gC_4 - (C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 + P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)) + (1 - x)(1 - y)(P_1(Q_1 - (n - 1)Q_2) - i_nC_4 - (C_2(Q_1 - nQ_2) + C_3Q_2) - C_4 + P_2(T_0 - T_1(Q_1 - nQ_2) - T_2Q_2)) \tag{9}$$

$$U_{32} = xy(P_1Q_1 - C_2Q_1 - P_2(T_1Q_1 - T_0) - F) + x(1 - y)(P_1Q_1 - C_2Q_1 - F - P_2(T_1Q_1 - T_0)) + (1 - x)y(P_1Q_1 - C_2Q_1 - P_2(T_1Q_1 - T_0)) + (1 - x)(1 - y)(P_1Q_1 - C_2Q_1 - P_2(T_1Q_1 - T_0)) \tag{10}$$

$$U_3 = zU_{31} + (1 - z)U_{32} \tag{11}$$

The enterprise's replicator dynamic equation can be obtained:

$$F(z) = \frac{dz}{dt} = z(U_{31} - U_3) = z(1 - z)(P_1Q_2 - C_4 - C_4i_n + Fx + Sx - C_3Q_2 - P_2Q_2T_2 + C_2Q_2n - P_1Q_2n - C_4i_gy + C_4i_ny + P_2Q_2T_1n) \tag{12}$$

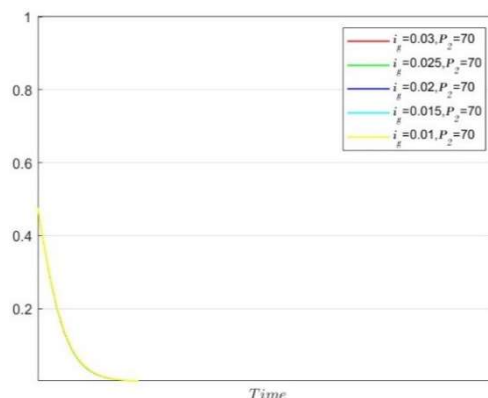
## 2.2. Numerical Simulation Analysis

According to calculations by the China Iron and Steel Association, the per-ton carbon emission for converter long-process steelmaking is 2.2 tons, and for EAF short-process steelmaking is 0.36 tons. Thus, we take  $T_1=2.2tCO_2/t$ ,  $T_2=0.36tCO_2/t$ . Based on the "Quota Total and Allocation Plan for the National Carbon Emission Trading Market in the Steel, Cement, and Aluminum Smelting Industries for 2024 and 2025" issued by the Ministry of Ecology and Environment, the quota surplus/deficit rate for enterprises with carbon emission intensity higher than the industry benchmark lies between 0% and -3%; here we take -3%, so  $T_0=0.043$  million tons. Currently, the carbon price in the national carbon market fluctuates around 70 RMB per ton, so the initial carbon price  $P_2=70$  RMB/ton. Other parameter assignments:  $i_n=3.5\%$ ,  $i_g=1.75\%$ ,  $r=1.0\%$ ,  $C_4=3$ , million RMB,  $Q_2=0.6$  million tons,  $S=60$  million RMB,  $n=1$ ,  $C_2=3122$  RMB,  $C_3=3330$  RMB,  $P_1=3426$  RMB,  $Q_1=2$  million tons,  $C_1=30$  million RMB,  $p=8$  million RMB,  $F=30$  million RMB,  $N_1=200$  million RMB,  $N_2=100$  million RMB.

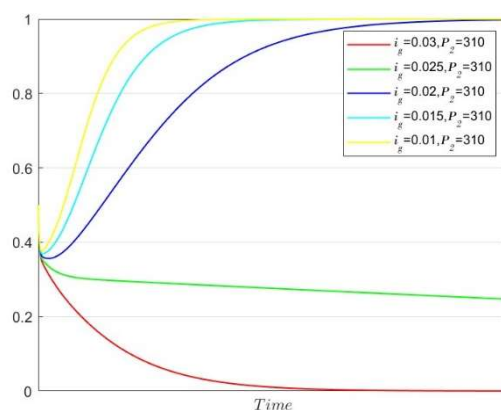
Based on the above values, Matlab R2024a was used to simulate the dynamic evolution process of strategy choices for steel enterprises under different initial states. The impact of the synergy between green credit policies and the carbon market on the green transition of steel enterprises is analyzed based on the simulation results.

### 2.2.1. Impact of Green Credit Interest Rate Level on Steel Enterprise Green Transition

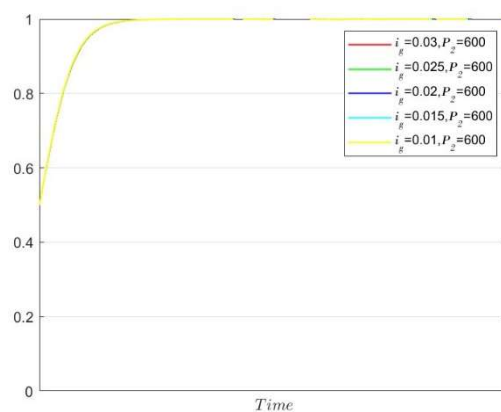
Figure 1 shows the impact of green credit interest rate levels on steel enterprise green transition under the current carbon price. It can be seen that at the current carbon price, even if the green credit interest rate is very low, steel enterprises still evolve and converge to the non-green transition strategy. Figure 2 shows the impact when the carbon price is 310. At this time, there is a threshold for the green credit interest rate; above this threshold, steel enterprises choose non-green transition, while below it, they choose green transition. Figure 3 shows the impact when the carbon price is 600. At this time, even if the green credit interest rate is very close to the traditional credit interest rate, steel enterprises will still choose green transition.



**Figure 1.** Impact of Green Credit Scale on the Green Transformation of Steel Enterprises when  $P_2=70$



**Figure 2.** Impact of Green Credit Scale on the Green Transformation of Steel Enterprises when  $P_2=310$



**Figure 3.** Impact of Green Credit Scale on the Green Transformation of Steel Enterprises when  $P_2=600$

As a typical high-carbon-emission and capital-intensive industry, the transformation decisions of steel enterprises are fundamentally governed by the economic rationality of transformation costs versus benefits.

When carbon prices are low, the marginal cost incurred by enterprises for excess emissions is far lower than the substantial incremental costs required for green technological upgrades. In this scenario, the carbon price signal fails, unable to effectively internalize environmental externalities. Consequently, even if green credit offers extremely low financing costs, it can only alleviate partial financial pressure without fundamentally altering the cost-benefit structure where maintaining the status quo remains more advantageous. Thus, the system evolutionarily stabilizes at a "no green transformation" strategy.

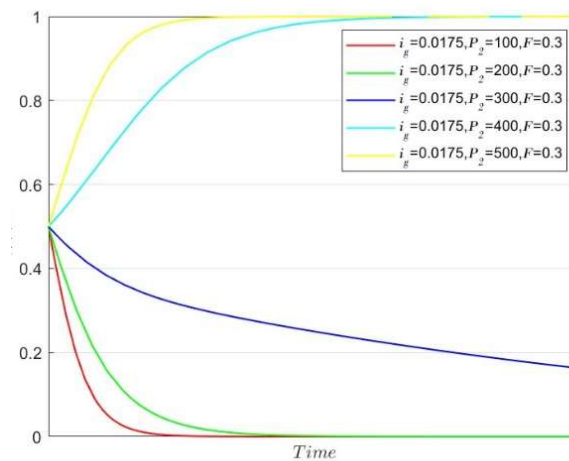
When carbon prices rise to a moderate level, carbon costs begin to significantly impact corporate profits, placing the potential benefits and additional costs of green transformation into a sensitive game-theoretic range. At this stage, the green credit interest rate becomes a critical threshold parameter: if it is sufficiently low, its combination with savings from carbon pricing can turn the net present value (NPV) of transformation projects positive, thereby guiding the system toward a green transformation equilibrium. Conversely, if the interest rate exceeds this threshold, financing costs will offset the gains from carbon pricing, and enterprises will still opt for conservative strategies. This indicates that in this phase, while carbon prices create the fundamental gravitational pull for transformation, green credit acts as a booster

determining whether the critical tipping point can be crossed, demonstrating a clear synergistic effect between the two.

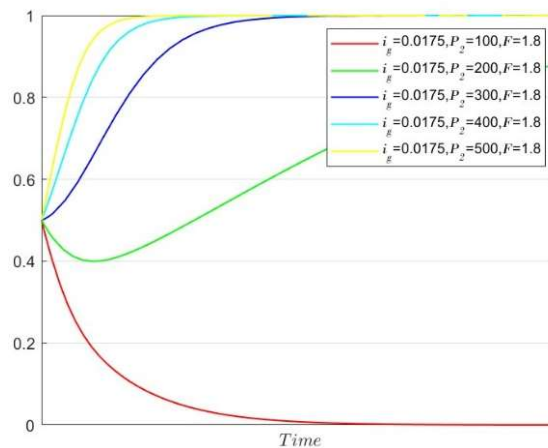
When carbon prices further escalate to sufficiently high levels, carbon constraints transform into powerful mandatory financial costs and risks, rendering the continuation of traditional high-carbon production models economically unviable. At this point, green transformation shifts from an optional project to a survival necessity; the long-term savings in carbon costs are sufficient to cover, and even far exceed, the comprehensive costs required for transformation. Under these circumstances, even if the interest rate advantage of green credit is marginal, the strong carbon price signal alone constitutes a sufficient economic incentive for enterprises to invest in green initiatives, with market mechanisms themselves playing the dominant role in resource allocation.

This series of dynamic processes indicates that for the steel industry, following its inclusion in the carbon market, effective drivers for green transformation rely on a clear and robust carbon price signal as the core foundation. Meanwhile, green finance policies must dynamically align with this signal, playing a pivotal role in lowering financial barriers to transformation at specific stages, thereby jointly forming a policy synergy that drives systemic industrial change.

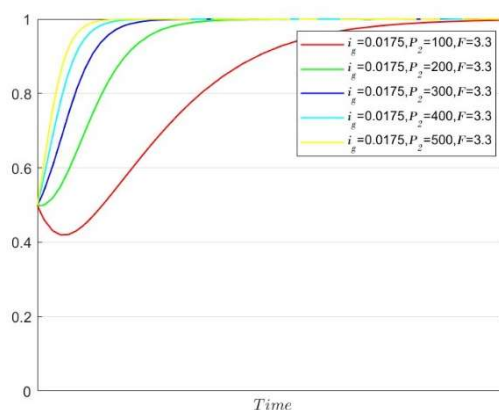
**2.2.2. Impact of Carbon Price Level on Steel Enterprise Green Transition**



**Figure 4.** Impact of Carbon Price Level on Green Innovation in Steel Enterprises when  $F=0.3$



**Figure 5.** Impact of Carbon Price Level on Green Innovation in Steel Enterprises when  $F=1.8$



**Figure 6.** Impact of Carbon Price Level on Green Innovation in Steel Enterprises when  $F=3.3$

Figures 4, 5, and 6 show the impact of carbon price levels on steel enterprise green transition under different government reward/punishment intensities, based on existing green credit interest rates. At low carbon prices, as the intensity of government rewards and punishments increases, the steel enterprise strategy evolution shifts from non-green transition to green transition. At high carbon prices, increasing the intensity of government rewards and punishments does not affect the result of steel enterprise strategy evolution; enterprises choose green transition in all cases.

In the low carbon price stage, both market mechanisms are in a state of failure. On one hand, the cost constraint of purchasing quotas is weak, insufficient to punish high-carbon production; on the other hand, the revenue incentive from selling quotas is equally weak. Even if enterprises generate surplus quotas through difficult transitions, the additional income they can obtain in the market is far from covering the huge initial investment. At this time, the cost-benefit trade-off for enterprises clearly favors maintaining the status quo. Government reward and punishment measures are crucial at this moment: by directly reducing transition costs through subsidies or increasing the cost of inaction through fines, they essentially create an alternative revenue-cost signal outside the carbon market to compensate for the insufficiency of market signals.

In the high carbon price stage, the dual mechanisms of the carbon market are fully activated, forming a powerful self-driving force. High carbon prices mean that non-transitioning enterprises will face continuous and heavy costs for purchasing quotas, while actively transitioning enterprises can obtain considerable additional revenue by selling surplus quotas. This "one negative, one positive" financial effect transforms green transition from a mere "compliance cost item" into an "investment profit item" with strategic value. In this context, the fundamental motivation for enterprises to invest in green initiatives shifts from "responding to external administrative orders" to internalizing the "pursuit of intrinsic financial optimization and competitive advantage construction." Therefore, as shown in Figures 2-5 and 2-6, additional government reward and punishment measures no longer significantly affect the final equilibrium, because a strong and effective carbon market, through its dual channels of cost and revenue, can spontaneously and efficiently guide resource flows towards green technologies. The government's role can accordingly shift from "front-end strong driving" to "back-end guarantee services," such as maintaining trading fairness, ensuring data transparency, and supporting basic technology R&D.

### 3. Conclusion

After introducing the carbon market, carbon price becomes the core variable driving green transition. Under low carbon prices, carbon market signals fail, and green credit struggles to function independently; under medium carbon prices, green credit and carbon prices form a complementary effect, jointly determining whether enterprises cross the transition threshold; under high carbon prices, carbon costs are fully internalized, and green transition shifts from a "compliance choice" to an "economic rationality." At this point, even if green credit incentives are limited, enterprises will actively choose green innovation. Furthermore, in low carbon price scenarios, government reward and punishment mechanisms can effectively compensate for market failures; while in high carbon price scenarios, the carbon market itself possesses sufficient guiding power, and the marginal utility of government intervention drops significantly.

In summary, the synergy between green credit and the carbon market is not a simple superposition but exists as a phased, conditional dynamic matching relationship. Only under the premise that carbon prices provide clear long-term expectations and administrative regulations set moderate boundaries can green financial tools precisely play the key role of "lowering financing thresholds and mitigating transition risks."

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