

# ***Government and Polluting Companies' Game Strategies in the Context of Green Finance***

## ***— A Prisoner's Dilemma Game Model***

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**Abstract:** Promoting the development of green industries to facilitate the growth of green finance has become a consensus among various sectors of society. This article focuses on the game theory strategies between governments and polluting companies in the context of green finance. Taking the Prisoner's Dilemma game model as an example, we discuss if polluting companies, under different types of governments, would choose to allocate loans towards improving production and environmental projects. Furthermore, we analyze whether the preferences of the general public towards eco-friendly products would influence the game strategies of governments and polluting companies. Through solving the model, we find that when governments increase penalties for polluting projects, reduce the costs of environmental project research and development for polluting companies, enhance environmental awareness among the general public, and stimulate their preference for eco-friendly products, they can strengthen corporate social responsibility and promote green investments. Consequently, polluting companies are more likely to invest in environmental projects to gain greater returns.

**Keywords:** green finance, local government, polluting companies, game theory, benefits

## **1. Introduction**

Green finance refers to the consideration of environmental factors in investment decisions made by financial institutions, directing more funds towards resource-saving technological development and eco-friendly industries [1]. Green finance encourages companies to focus on ecological conservation and promotes the adoption of a green consumption concept among consumers. It also emphasizes the principle of sustainable development for the financial industry, discouraging excessive speculative behaviors driven by short-term gains.

The Prisoner's Dilemma game model is widely used to study the applications of game theory in various fields, including environmental economics and finance. Within the context of green finance, the strategic interaction between the government and polluting companies has become an important research area. In the traditional Prisoner's Dilemma game model, two prisoners face the choice of cooperation or betrayal. However, in the context of green finance, the game strategies between the government and polluting companies are more complex. The behavior of polluting companies directly impacts the environment and public welfare. In order to achieve environmental sustainability and

financial stability, the government needs to adopt effective game strategies to guide the behavior of polluting companies.

The rest of the paper is structured as follows: Section 1 describes the basics of the problem. Section 2 provides a detailed analysis of the game process between the government and polluting companies. Section 3 presents conclusions and policy recommendations. Section 4 presents the conclusions of the study. This paper analyzes the game strategies between the government and polluting companies from the perspective of the Prisoner's Dilemma Game. At the end of the analysis, it compares the interests of both sides of the game in all situations, and makes recommendations on how to create a "win-win" situation between the government and polluters in the process of the game.

## 2. Problem Description

On August 31, 2016, the People's Bank of China, along with seven other departments, issued the "Guidance on Accelerating the Development of Green Finance." This landmark move positioned China as the first economy to establish a relatively comprehensive policy framework for green finance. In recent years, China's green finance policies have been steadily advancing, and the construction of a green financial system has matured, leading to the development of various green financial products and channels, such as green loans, green funds, green insurance, and green guarantees [2]. According to the Climate Bonds Initiative, based on its classification standards, China surpassed France in 2021 to become the world's third-largest issuer of green bonds [3]. This indicates that some countries and regions have developed mature green finance-related institutions and promote green development through green finance, which is increasingly becoming a global consensus. The green credit balance and quarterly growth rate in China from 2020 to 2022 are shown in figure 1.

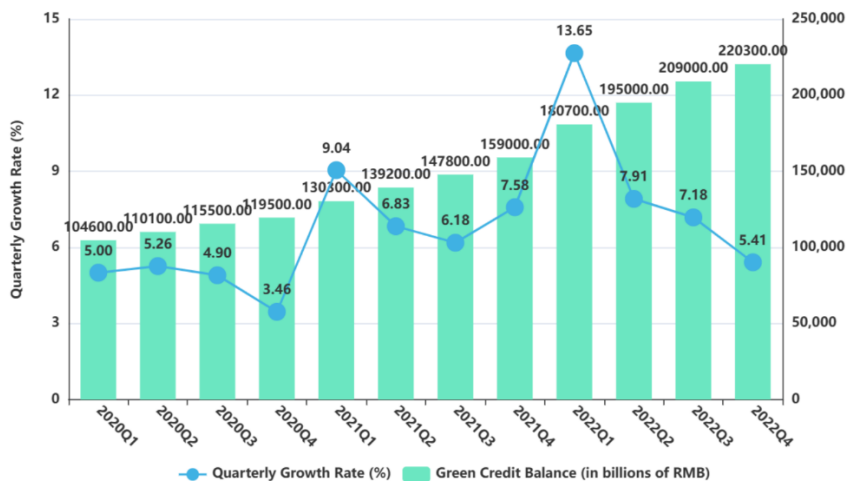


Figure 1: Green Credit Balance and Quarterly Growth Rate in China from 2020 to 2022.

In January 2021, General Secretary Xi Jinping emphasized China's goal of achieving a peak in carbon dioxide emissions by 2030 and carbon neutrality by 2060 during the World Economic Forum. Green finance not only plays an important role in achieving these goals but also contributes to green and sustainable economic growth, thereby contributing to solving global climate and environmental issues.

This paper analyzes the game strategies between the government and polluting companies in the context of green finance from the perspective of the Prisoner's Dilemma Game. The game involves the government and polluting companies as players. As the regulator of corporate economic activities,

government measures directly influence corporate decision-making. The government is categorized as either a strict government or a non-strict government. A strict government emphasizes green finance and related polluting companies, conducting inspections and imposing penalties if the companies fail to meet environmental standards. A non-strict government may not promptly detect polluting companies or impose penalties on them. Polluting companies acquire loans from banks or other channels and can choose to allocate the loans towards improving production, environmental projects, or other channels.

### **3. Game Process**

#### **3.1. Model Assumptions**

Before the game analysis, several assumptions are proposed to increase the credibility and accuracy of the model analysis. The assumptions are as follows: firstly, both parties are rational and risk-averse, making decisions based on their self-interests. Secondly, there is perfect information exchange between the government and polluting companies, and each party understands the benefits derived from choosing a specific strategy. Thirdly, all projects funded by loans for polluting companies generate profit [4]. Companies have the freedom to allocate their income. Lastly, the game players are independent, and collusion does not occur.

#### **3.2. Symbol Setting**

The following symbols are used in this paper:  $M$  - the revenue obtained by polluting companies when loans are allocated towards improving production and environmental projects;  $N$  - the revenue obtained by polluting companies when loans are allocated towards other channels;  $B$  - the baseline revenue obtained by the government through its regular operations, unaffected by government types or other factors;  $P$  - the additional cost incurred by polluting companies when investing in production improvement and environmental projects;  $Q$  - the penalty imposed on polluting companies by the government due to environmental failures[5].

#### **3.3. Game Analysis**

##### **3.3.1.No Apparent Preference for Eco-friendly Products Among the Public**

When the general public does not show a clear preference for environmentally friendly products, polluting companies allocate their loans equally between improving production, environmental projects, and other sources of revenue, represented by  $M=N$ . Analyzing all potential combinations between the government and polluting companies, the following four scenarios arise: When polluting companies allocate loans towards improving production and environmental projects and the government is a strict government, the company's revenue is  $M - P$ , and the government's revenue is  $B$ . When polluting companies allocate loans towards improving production and environmental projects and the government is a non-strict government, the company's revenue is  $M - P$ , and the government's revenue is  $B$ . When polluting companies allocate loans towards other channels and the government is a strict government, the company's revenue is  $N - P$ , and the government's revenue is  $B + Q$ . When polluting companies allocate loans towards other channels and the government is a non-strict government, the company's revenue is  $N$ , and the government's revenue is  $B$ . The game matrix is shown in Figure 2.

		Government	
		Strict government	Non-strict government
Companies	Environmental	$M-P, B$	$M-P, B$
	Not environmental	$N-P, B+Q$	$N, B$

Figure 2: Game Matrix between the Government and Polluting Companies.

By solving the model, for the government, when polluting companies allocate loans towards improving production and environmental projects, the government type does not affect its revenue. When polluting companies allocate loans towards other channels, a strict government is the optimal choice. For polluting companies, if the government is a non-strict government, they will not choose to invest in environmental projects. Only when the government is a strict government and when  $P < Q$ , will polluting companies choose to invest in environmental projects.

### 3.3.2. Preference Towards Eco-friendly Products Among the Public

When the general public show a clear preference for environmentally friendly products, polluting companies allocate a larger portion of their loans towards improving production, environmental projects, and other sources of revenue, represented by  $M > N$ . Analyzing the same four scenarios mentioned earlier, we obtain the same game matrix as presented in Table 1. By solving the model, for the government, when polluting companies allocate loans towards improving production and environmental projects, the government type does not affect its revenue. When polluting companies allocate loans towards other channels, a strict government is the optimal choice. For polluting companies, when  $M - P > N$ , i.e., when the net revenue from improving production and investing in environmental projects exceeds the revenue from allocating loans towards other channels, they will choose to invest in the environmental projects.

## 4. Policy Recommendations

Through game model analysis, the following conclusions are drawn: Compared to the cost of polluting companies allocating loans towards environmental projects, a strict government's higher penalty cost ensures that the revenue from allocating loans towards other channels is significantly lower than the revenue from investing in environmental projects. Consequently, companies will increase their investment in environmental projects. Additionally, if polluting companies reduce the costs of investing in environmental projects, they will be more motivated to engage in such projects. The public's strong preference for environmentally friendly products can also lead polluting companies to increase their investments in environmental projects. Based on the above conclusions, the following suggestions are proposed:

### 4.1. Increase the Punishment for Non-environmental Behavior by Polluting Companies

The previous model analysis reveals that the fundamental reason why polluting companies do not allocate loans towards environmental projects lies in their lack of motivation. Polluting companies' decisions are based on self-interest, and increasing the punishment cost, enhancing the deterrence capability of the government can make the revenue from allocating loans towards other channels

significantly lower than the revenue from investing in environmental projects, thereby encouraging companies to increase investment in environmental projects. During law enforcement, the government should adopt reasonable measures, ensuring the clarity of rewards and punishments, using evidence-based and fair law enforcement, and developing policies and measures tailored to the actual situation of polluting companies.

#### **4.2. Encourage Polluting Companies to Engage in Technical Research and Development for Environmental Projects**

The model analysis reveals that when the costs of technical research and development for environmental projects decrease, polluting companies become more motivated to invest in such projects. Therefore, the government needs to encourage polluting companies to engage in relevant research and development. This can be achieved by providing financial subsidies or tax incentives to companies conducting environmental research and development, effectively reducing their costs.

#### **4.3. Increase Public Awareness of Environmental Protection and Preference for Eco-friendly Products**

The model analysis demonstrates that when the public exhibits a clear preference for eco-friendly products, polluting companies' revenue from allocating loans towards environmental projects increases, thereby incentivizing them to increase investments in environmental projects. Hence, the government should raise public awareness of the importance of ecological conservation, emphasizing the relevance of environmental protection to personal interests and the interests of future generations. Simultaneously, the government should encourage the public to prioritize the purchase of eco-friendly products in daily life by promoting the concept of eco-friendly consumption, providing preferential treatment and policy support, and stimulating the demand for eco-friendly products. Consequently, companies will increase the supply of eco-friendly products, enhance research and development in environmental projects, and increase their investments. This will lead to a price increase, thereby creating a virtuous cycle.

#### **4.4. Strengthen Corporate Social Responsibility to Promote Green Investment**

Compared to the previous three policy types, strengthening corporate social responsibility is a low-cost yet effective policy measure. In the public information of large financial institutions and listed companies in some developed countries, social responsibility has become one of the corporate objectives. Methods to strengthen corporate social responsibility include requiring companies to disclose the environmental impact of their invested projects, establishing a system of legal liability for investors, and enhancing education on green awareness among investors. Strengthening corporate social responsibility will encourage businesses to allocate more resources to environmental projects, promote green investment, and contribute to the development of green finance.

### **5. Conclusion**

From the perspective of the prisoner's dilemma game model, the decision of polluting companies is influenced by the type of government. When the government is strict and the cost of punishment for polluting companies is high, the polluting companies will invest their loans into environmental projects to obtain higher returns. If the research cost for environmental projects is low, the companies will also increase their investment in these projects and develop mature technologies at a lower cost, thereby gaining higher profits. If there is a clear preference for environmentally friendly products among the public, polluting companies will increase their investment in environmental projects to

improve the supply of such products. When the market reaches equilibrium, the prices of these products will increase, resulting in higher profits for the polluting companies.

The government can encourage polluting companies to allocate funds to environmental projects and facilitate the development of green finance from multiple aspects. On one hand, increasing penalties for non-environmentally friendly behavior by polluting companies can fundamentally improve their motivation to engage in technological research and development for environmental projects. On the other hand, raising public awareness of environmental protection and strengthening the sense of social responsibility among polluting companies can achieve good results at a relatively low cost.

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