Green innovation, government incentive and enterprise performance are explored from the perspective of game

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Abstract: The rapid development of economy brings serious environmental pollution problem. Green innovation, as the connection point between government environmental regulation measures and sustainable green development of enterprises, has become one of the important choices for the transformation and development of enterprises. Based on the classic model of "prisoner's dilemma" in game theory, this paper deeply analyzes the relationship between green innovation and performance. It is found that it is easy to get into trouble if only relying on the spontaneous green innovation within the enterprise. Applying appropriate pressure outside the enterprise can promote the change of green innovation and bring long-term benefits to the enterprise.

1 Introduction

In recent years, the contradiction between environmental protection and economic development has become more and more prominent, so the development of green economy has become the focus of current economic development. As a kind of change, innovation is the decisive force to promote social sustainable development. Under the guidance of the concept of green development, green innovation has become the key driving force to realize the development of low-carbon economy and improve the efficiency of natural resources.

Green innovation is different from traditional innovation. It integrates green and innovation, and emphasizes ecology more. It is the key choice for enterprises to carry out green transformation and improve performance[1]. At present, researches on green innovation mostly focus on green product, green process and green management. Green product innovation can fully tap the blind area of resource utilization, encourage enterprises to explore new development channels, and ultimately improve enterprise performance; green process innovation can reduce the operating costs of enterprises, alleviate the regulatory pressure of enterprises due to pollutant emissions, and has more advantages than disadvantages for the performance growth of enterprises in the early stage of transformation; Green management innovation can help enterprises obtain information, capture development opportunities, and play a catalytic role in green product and green process innovation through management process control. Green innovation is a long-term dynamic evolution process, which requires enterprises to constantly seek new resources and seize new opportunities. At the same time, they should constantly optimize the internal management and operation structure, improve product quality, meet market demand and conform to the development trend of the times. Under the joint action of the key elements inside and outside the enterprise, it can make the enterprise different from competitors, win the favor of consumers, and then improve the enterprise performance.

In the context of China's economic new normal and economic transformation, market and government macro-control play a role in China's economic field. As a resource-based enterprise in China, its survival and growth mainly depend on the consumption of national natural resources[2]. At the same time, its production and operation has a strong negative externality, which makes the development of resource-based enterprises more vulnerable to the influence of external government behavior. As a financial contribution or help provided by government agencies to enterprises, whether government subsidies for environmental protection will have an incentive effect on enterprises' green innovation has always been a hot topic in academic circles. At present, there are many researches on the impact of government incentives (mainly environmental subsidies) on green innovation at home and abroad, but the conclusion has always been controversial. One is that government subsidies can reduce R & D costs and risks of enterprises, which has a positive incentive effect on enterprise innovation. The other is that there is a substitution effect between government subsidies and enterprise innovation. For enterprises, the ultimate goal is to maximize their own interests, and green innovation is the choice under the requirements of environment, policies and regulations. The willingness of spontaneous green innovation within enterprises is not high, especially for China's listed enterprises under the influence of long-term planned economic system[3]. When listed companies carry out green innovation activities, they

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must take environmental factors into account in their development strategies, which are more or less in conflict with their goal of maximizing economic benefits. However, under the pressure of the market and the government, innovation without green factors can no longer bring more benefits to enterprises. Under the pressure of government supervision, public opinion supervision and market regulation, the level of enterprise environmental information disclosure has been significantly improved, and the improvement of the quality of environmental information disclosure also means that the work and achievements of enterprise environmental protection are relatively good, which is in line with the goal of green innovation. The higher the level of product market competition, the more enterprises tend to carry out green innovation and R & D, and expand the competitiveness of the company through green products to obtain greater market share; Secondly, through the R & D and improvement of green innovation, we can control the production cost and waste disposal cost to a greater extent; In addition, through the optimization of green innovation R & D, it is conducive to improve the function of environmental management system, and effectively restrain the possible earnings management in the process of green innovation, so as to significantly enhance the role of green innovation in improving financial performance. On the other hand, the greater the pressure of performance expectations and government intervention, the more incentive enterprises can implement green innovation strategy, and effectively improve the efficiency of green innovation. From this we can see that the external pressure of government and market not only does not hinder the implementation of green innovation strategy, but also has a better positive promoting effect.

At present, most of the researches on green innovation focus on the influence of environmental regulation on enterprises' green innovation behavior, whether the internal factors of enterprises can promote enterprises' green innovation strategy and the promotion of market structure on enterprises' green innovation[6]. Few researches analyze the relationship between green innovation, enterprise performance and government incentive from the perspective of game theory. From the perspective of game theory, this paper analyzes in detail whether green innovation can promote the performance growth of heavy polluting enterprises and the role of government incentives through the classic model of "prisoner's dilemma" in game theory, which provides theoretical support for enterprises to make green innovation decisions.

2 Materials and Methods

Prisoner's dilemma is one of the two classical models of game theory. In 1950, Merrill Froude and Melvin drehill summed up the theory of related dilemma. Albert Tucker used the prisoner's situation to elaborate on it, and named it "prisoner's dilemma". The specific expression of the model is: two criminals were caught by the police when the gang committed crimes, but the police lacked sufficient evidence to testify against them. In order to solve the case as soon as possible, at least one of the two criminals must plead guilty. At the same time, in order to prevent them from colluding in confessions, the police decided to interrogate them separately and told them "lenient if they confess and strict if they resist". The specific enforcement measures are as follows: if one of the two criminals confesses and the other denies, the confessor will be acquitted because of his meritorious performance, and the denier will be sentenced to five years' imprisonment because he does not know how to repent; If both parties confess at the same time, they will be sentenced to three years' imprisonment because the facts of the crime are clear; If both sides deny at the same time, the police can only think that the criminal interferes with his official duties because of insufficient evidence, and will be sentenced to one year's imprisonment. The benefits of the two criminals are shown in Table 1.

|               | Prisoner 2 defect | Prisoner 2 cooperate |
|---------------|-------------------|----------------------|
| Prisoner 1 defect | (-3,-3)           | (0,-5)               |
| Prisoner 1 cooperate | (-5,0)         | (-1,-1)              |

In the prisoner’s dilemma model, every criminal is selfish, and they will only consider their own best benefits, not others' benefits. In other words, in the absence of any external forces to intervene in their own decision-making, criminals will strictly follow their own wishes and choose the most suitable strategy for their own interests. In this model, no matter what the other party's strategy is, the benefit of voluntary confession is much stronger than that of denial. So the Nash equilibrium of prisoner's dilemma is (confession, confession). In real life, the so-called alliance is not so strong, everyone is selfish, no one will follow the verbal agreement in front of huge interests. Prisoner's dilemma model is mainly applied to the decision-making choice when both sides of the game face the risk of loss, so it is used to analyze whether the enterprise should carry out green innovation when facing the problem.

3 Results & Discussion

3.1 Green innovation dilemma analysis of homogeneous enterprises

With the rapid development of science and technology, China's economy has made remarkable achievements. However, after entering the 21st century, with the change of consumer consumption concept from the pursuit of cost performance to green consumption, the traditional food retail, architectural decoration, automobile industry, financial payment and other industries are increasingly unable to meet the green consumption needs of consumers. Traditional enterprises
are facing unprecedented difficulties, and Chinese traditional enterprises are in urgent need of transformation and upgrading. At the same time, enterprises and government departments have realized the importance of promoting enterprises' green innovation, accelerating enterprises' going out and improving enterprises' green competitiveness. However, if enterprises carry out R & D activities of green innovative products, they will increase the investment in R & D to a great extent. In a short period of time, green innovation will not bring considerable benefits, but will lead to the rupture of enterprise capital chain or the loss of market competitive advantage, which will lead to the serious consequences of withdrawing from the market[5]. Therefore, whether enterprises carry out green innovation constitutes a game process.

(1) Basic assumptions of the model:
Participants:
Homogeneous enterprises i (i = 1,2)
Strategy:
Enterprise 1,2 are both (carray, refuse)
Payment function:
The profit of enterprises without green innovation is PN and the cost is CF; The profit of green innovation constitutes a game process.
PN+PD-CF-CV > PN-CF, enterprise 1 will choose green innovation; When enterprise 2 chooses green innovation, PN+PD-CF-CV+PG > PN-CF, enterprise 2 will choose green innovation.Similarly, when enterprise 1 chooses not to carry out green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 2 will choose green innovation;When enterprise 1 chooses to carry out green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 2 will choose green innovation;When enterprise 2 chooses not to carry out green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 1 will choose green innovation;When enterprise 2 chooses green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 1 will choose green innovation. The Nash equilibrium formed at this point is (carray, carray), that is, both enterprises 1 and 2 carry out green innovation.

(2) Model solution and analysis

By analyzing the above model, we can find that when PD-CV < 0, PN+P_D-C_V-C_V < P_N-C_F. Using the marking method, we can get that the pure strategy Nash equilibrium of the game is (refuse, refuse), that is, enterprise 1 and enterprise 2 do not carry out green innovation; When PD-CV > 0, PN+P_D-C_V > P_N-C_F. Using the marking method, we can get the pure strategy Nash equilibrium of the game as (carray , carry ), that is, both enterprise 1 and enterprise 2 carry out green innovation.

(3) Main conclusions
In reality, in the short-term operation of enterprises, the income from green innovation is far less than the cost of R & D. However, with the increase of practice, the cost of green innovation will gradually decrease due to the improvement of technology and the innovation of management. Coupled with the competitive advantage brought by green products, the income will gradually increase. However, most enterprises only focus on the short-term interests. First, the goal of enterprises is to maximize the interests. Green innovation will affect the short-term interests; Second, most enterprises have to pay attention to the short-term interests, because they have less working capital. After putting a lot of money into green innovation, they can not get the expected benefits. Once they encounter emergencies, it is likely to cause the rupture of the internal capital chain, and then lead to a series of serious consequences. From the perspective of long-term interests, green innovation is the best choice for enterprises, but they are afraid of the rapid collapse of enterprises in the short term, thus falling into a dilemma, which is the so-called "prisoner's dilemma".

3.2 Game between homogeneous enterprises under government incentive

Government subsidies can improve the short-term lack of funds for enterprises[wang], enable enterprises to survive and achieve considerable development, and greatly stimulate the vitality of the market[6]. Therefore, the appropriate increase of subsidies is beneficial to the development of enterprises and the good operation of the market, but with it comes more fierce competition between enterprises, which forms a further game.

(1) Basic assumptions of the model
Participants:
Homogeneous enterprises i (i= 1,2)
Strategy:
Enterprise 1,2 are both (carray, refuse)
Payment function:
When the enterprise does not carry out green innovation, the profit obtained is PN and the cost is CF. When green innovation is carried out by enterprises, the income is PN+PD, the cost is C_F+C_V, and the government subsidy is P_G. The benefit matrix of the two enterprises is shown in Table 3:

Table 3. Game matrix between enterprises under government incentive

(2) Model solution and analysis
Through the analysis of the above models, if PG+PD-CV>0, and using the line method, when enterprise 1 chooses to carry out green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 2 will choose green innovation;When enterprise 1 chooses not to carry out green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 2 will choose not to carry out green innovation.Similarly, when enterprise 2 chooses green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 1 will choose green innovation;When enterprise 2 chooses not to carry out green innovation, P_N+P_D-C_V+P_G > P_N-C_F, enterprise 1 will choose to carry out green innovation. The Nash equilibrium formed at this point is (carray, carray), that is, both enterprises 1 and 2 carry out green innovation.

(4) Main conclusions
For a resource-based enterprise, it is very difficult to carry out the reform of green innovation. First, because of the large organizational inertia of traditional enterprises, it is not easy to change. Second, the short-term benefits brought by green innovation may go against the original intention of maximizing the interests of the enterprise. Therefore, the willingness of spontaneous green innovation within the enterprise is not enough, and it does not meet the expectations of the government. Therefore, the government needs to subsidize the green innovation of enterprises to a certain extent, so that they can survive the crisis. At the same time, the government should strengthen supervision to prevent some enterprises from cheating and wasting national resources under the name of green innovation.

4 Conclusions

Based on the classic model of "prisoner's dilemma", this paper analyzes the impact of green innovation on the performance of enterprises, and explores whether the government incentive can effectively solve the problems of enterprises. The conclusions are as follows: (1) for enterprises, the ultimate goal is to maximize their own interests, and green innovation is the choice under the requirements of environment, policies and regulations. Although it may occupy a certain opportunity in the future market, the willingness of enterprises to carry out green innovation spontaneously is not high. (2) In order to pursue interests, homogeneous enterprises of similar scale refuse to carry out green innovation research and development first; For homogeneous enterprises of different scales, it is usually the large enterprises that carry out green innovation R & D first. (3) Under the condition of government subsidies to green innovation, enterprises are expected to get out of the "prisoner dilemma", and make all enterprises compete for green innovation, and comprehensively promote the green transformation of enterprises.

The above research expounds the difficult choices faced by enterprises in the face of the strategic choice of green innovation under the situation of environmental deterioration and severe environmental regulation, and highlights the inevitable choice of enterprises in green innovation, which provides strong theoretical support for enterprises to seize the opportunity to carry out green innovation, and suggests that the government can strengthen the government regulatory functions, improve the system and legal system, In order to stimulate the vitality of the market and promote social development, we should adopt diversified supervision means and use subsidies to help enterprises tide over difficulties.

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