Study on Equilibrium Relationship Between Government Regulation and Social Environmental Responsibility of Energy Enterprises

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Abstract. This paper uses the evolutionary game model to analyze the relationship between government regulation and social environmental responsibility of energy enterprises. Then, we use the Matlab to simulate the dynamic change between government regulation and social environmental responsibility of energy enterprises. The conclusion of the study shows that: (1) The strategic choice based on corporate social environmental responsibility is must be the green technology innovation, and if we want to the maximum profit, we need to find a balance between government regulation and corporate social environmental responsibility. (2) Whether the government supervises enterprise, whether an enterprise fulfills its social environmental responsibility, depends on the specific circumstances. We must take an overall consideration of the cost of government, the bonuses, and penalties, the corporate different earnings because of different choices between fulfills and defaults its social responsibility, the bonuses the company achieved, the penalties the company must pay, and many other factors. The main contribution of this thesis is: break through the static research about the relationship between government and energy enterprise. We acquire the dynamic relation between government and energy enterprise based on green technology innovation. And it provides great help for our energy companies future direction of development.

1. Introduction

Neoclassical economic theory holds that enterprises are "rational people" and seeks to maximize their profits under conditions of scarce resources. Scholars represented by Milton Friedman (1970) believe that corporate profit targets and social responsibility have an inherent tension, that is, the two forces have opposite directions and depend on and support each other. Enterprises must effectively fulfill their social responsibilities. At the same time, the so-called commitment to corporate social responsibility means merely participating in public welfare activities, which is regarded as a part of the cost that the company must spend but does not see the long-term competitive advantage that corporate social responsibility brings to the company, so it is impossible to take corporate social responsibility. Endogenization (Chen Weizheng et al., 2002).

There have been many achievements in research on corporate social responsibility. Carroll (1979) first incorporated stakeholders into the social responsibility framework, thus forming a new conceptual
framework for CSR. The article published by Porter and Kramer (2006) in Harvard Business Review systematically analyzes the relationship between competitive advantage and corporate social responsibility and explains how companies can find opportunities for corporate social responsibility through competitive strategies and produce more products that society needs. To gain a long-term competitive advantage, Chih-Chen Liu and Wang (2015) found that companies are certified by NGO (Non-Governmental Organization) and have an incentive to undertake environmental corporate social responsibility (ECSR). For certification standards, Cournot competition is higher than that of Burland competition, and more importantly, both companies and consumers can benefit from environmental corporate social responsibility. Some scholars believe that corporate social responsibility will lead to a reduction in its output and a decline in profits. Porter and Kramer believe that the reason may be that companies take social responsibility as part of the cost. More importantly, these companies have not made efforts to achieve corporate social responsibility as part of their competitive strategy. Especially in the buyer’s market, consumer preferences will directly enter the objective function of the enterprise. In this case, if the competitive strategy of the enterprise is “altruistic” or "beneficial to consumers", we can regard corporate social responsibility as a This management strategy analyzes its potential economic role.

This article believes that the combination of corporate dynamic growth theory, innovation theory, and corporate social responsibility to explain the problem of corporate sustainable growth is a trend of further development, and it is even more necessary to quantify the relationship between the three models. The research focus of this paper is to prove that companies that succeed in market competition and maximize consumer surplus and social welfare are not a zero-sum game. Enterprises not only pursue their profits but also consumer recognition. The marginal contribution of this paper is that it internalizes corporate social responsibility. Through the evolutionary game model of corporate growth and government environmental regulation, it provides a theoretical basis for the realization of sustainable growth of enterprises and sustainable development of the economy.

2. Theoretical model

2.1. Model building

This article assumes that there are two types of entities in the market: the government and the enterprise. The enterprise fulfills its social responsibilities through green technology innovation. At this time, the additional income obtained by the enterprise is R1, including the cost savings of green technology innovation, and the increase in sales due to environmental protection reputation. Increased profits for enterprises, and reduced pollution control costs later, and minus costs and expenses caused by green technology innovation. The enterprise’s income from non-green technological innovation is R2, and R1>R2.

References are cited in the text just by square brackets [1]. Two or more references at a time may be put in one set of brackets [3, 4]. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under heading references, see our example below.

At the same time, the government supervises enterprises by designing reward and punishment mechanisms. The corresponding subsidy A1 for enterprises receiving environmental responsibilities is C1 (such as recruiting relevant staff to visit and survey, collecting pollution information around the enterprise, investigating pollution sources, and assessing whether the enterprise has paid the manpower and material resources for fulfilling environmental responsibilities, etc.). On the contrary, the company is fined B1, and the corresponding regulatory cost is C2 (including the cost C1 required for government supervision, plus the cost of governance of environmental pollution caused by the government's failure to fulfill its environmental responsibilities later). In this paper, the probability that the government can effectively supervise is denoted by p, and the probability of an enterprise performing social responsibility is denoted by q, and 0 ≤ p ≤ 1, 0 ≤ q ≤ 1.
Table 1 Main Variables

| Enterprise fulfills social responsibilities | Enterprise does not fulfill social responsibilities |
|---------------------------------------------|-----------------------------------------------------|
| Enterprise earnings                        | $R_1$                                               |
| Government regulation cost                 | $C_1$                                               |
| Enterprise subsidies                       | $A_1$                                               |

Table 2 Payment matrix of both parties

| Government | Enterprise |
|------------|------------|
| Supervisor (p) | $q$ | $1-q$ |
| $(-A_1 - C_1, R_1 + A_1)$ | $(-C_1 - C_2 + B_1, R_2 - B_1)$ |
| No Supervisor (1-p) | $(0, R_1)$ | $(-C_2, R_2)$ |

According to the dynamic equation:

$$\frac{dp}{dt} = p[\varepsilon D_1 Q^T - PD_1 Q^T]$$  (1)

$$\frac{dq}{dt} = q[\varepsilon D_2 P^T - QD_2 P^T]$$  (2)

Where $D_1 = \begin{bmatrix} -A_1 - C_1 & -C_1 - C_2 + B_1 \\ 0 & -C_2 \end{bmatrix}$, $D_2 = \begin{bmatrix} R_1 + A_1 & R_2 - B_1 \\ R_1 & R_2 \end{bmatrix}$, $D_i (i = 1, 2)$ respectively represent the payment matrix of the government and the enterprise. Let the unit vector be $\varepsilon = [1, 0]$. $P = \{p, 1 - p\}$ means the mixed strategy adopted by the government (supervision and non-supervision), and $Q = \{q, 1 - q\}$ means the enterprise’s mixed strategy. The dynamic equation for the reproduction of corporate social responsibility is:

$$\frac{dp}{dt} = p(1 - p)[-q(A_1 + B_1) + (B_1 - C_1)]$$  (3)

$$\frac{dq}{dt} = q(1 - q)[p(A_1 + B_1) + (R_1 - R_2)]$$  (4)

The Jacobian matrix of the above system is:

$$J = \begin{bmatrix} (1 - 2p)[-q(A_1 + B_1) + (B_1 - C_1)] & -p(1 - p)(A_1 + B_1) \\ q(1 - q)(A_1 + B_1) & (1 - 2q)[p(A_1 + B_1) + (R_1 - R_2)] \end{bmatrix}$$  (5)

In a dynamic system, if the trajectory in a field with a sufficiently small equilibrium point eventually tends to change, then the equilibrium point is locally progressively stable (Hirshleifer, 1988). At the same time, Friedman (1991) proposed to obtain the stability of the local equilibrium point through the local stability analysis of the Jacobian matrix. The determinants and traces corresponding to the above matrix are:

The determinant of the matrix is:

$$\det J = (1 - 2p)(1 - 2q)[-q(A_1 + B_1) + (B_1 - C_1)][p(A_1 + B_1) + (R_1 - R_2)]$$

$$+ pq(1 - p)(1 - q)(A_1 + B_1)^2$$  (6)
The trace of the matrix is:

\[ \text{tr}(J) = \det J = (1 - 2p)\left[-q(A_i + B_i) + (B_i - C_i)\right] + (1 - 2q)\left[p(A_i + B_i) + (R_i - R_2)\right] \]  

(7)

2.2. Model analysis

According to the stability conditions of discrete dynamic systems, the equilibrium point is stable if and only if \( \det J > 0 \) and \( \text{tr}(J) < 0 \). Let \( \frac{dp}{dt} = 0 \), to get the possible stable state of the government: \( P_2 = 0, \ P_2 = 1, \ P_3 = \frac{B_i - C_i}{A_i + B_i} (0 \leq \frac{B_i - C_i}{A_i + B_i} \leq 1) \), it can be obtained by the same reason, the possible stable point of the enterprise group is \( q_1 = 0, \ q_2 = 1, \ q_3 = \frac{R_2 - R_1}{A_i + B_i} (0 \leq \frac{R_2 - R_1}{A_i + B_i} \leq 1) \).

According to this, five equilibrium points in the evolutionary game of corporate social responsibility and government supervision under the conditions of green technology innovation are obtained: \((0, 0), \ (0, 1), \ (1, 0), \ (1, 1) \) and \( (R_2 - R_1, \ B_i - C_i) \). The local stability of the evolutionary game will be discussed separately below.

(1) \( B_i > C_i, \ R_2 - B_i > A_i + R_1 \)

When the fine income obtained by the government is greater than the expenses paid for supervision, and the sum of the enterprise's income and the government's reward for the enterprise is less than the enterprise's income minus the fine imposed by the government, it does not satisfy the condition \( 0 \leq \frac{R_2 - R_1}{A_i + B_i} \leq 1 \), calculate \( \det J \) and \( \text{trace} \ J \) of each equilibrium point, the results are shown in Table 3.

**Table 3** Stability analysis when government supervision costs are low and companies execute only few of their social responsibilities

| LEP   | \( \text{det} J \)                                           | \( \text{trace} J \)                                           | Results         |
|-------|------------------------------------------------------------|---------------------------------------------------------------|-----------------|
| (0, 0) | \( (B_i - C_i)(B_i - R_2) \)                              | \( (B_i - C_i)(B_i - R_2) \)                                   | Saddle point    |
|       | \( (A_i + C_i) - (R_i - R_2) \)                            |                                                               |                 |
| (0, 1) | \( (A_i + C_i)(R_i - R_2) \)                               |                                                               | Saddle point    |
|       | \( -(A_i + C_i) - (R_i - R_2) \)                           |                                                               |                 |
| (1, 0) | \( -(B_i - C_i)(A_i + B_i) + (R_i - R_2) \)                |                                                               | ESS            |
|       | \( -(B_i - C_i)(A_i + B_i) + (R_i - R_2) \)                |                                                               |                 |
| (1, 1) | \( -(A_i + C_i)(R_i - R_2) + (A_i + B_i) \)                |                                                               | Unstable        |
|       | \( (R_i - R_2) - (B_i - C_i) \)                            |                                                               |                 |

It is not difficult to see from Table 3 that when the cost of government supervision is low and the company performs less social responsibility, the equilibrium point is \((1, 0)\). The government chose to strengthen supervision because the government's supervision costs are lower. In the supervision process, the fines obtained from supervision until the company fails to fulfill its social responsibilities are higher, which further promotes the government to strengthen supervision. For an enterprise, if the enterprise finds that its reduced profits (including deducted government supervision fines) due to non-performance of social responsibility are still higher than the income obtained by the enterprise for performing social responsibilities and government rewards, the enterprise will inevitably choose to save time and effort Do not fulfill their social responsibilities.

(2) \( B_i > C_i, \ 0 < R_2 - R_1 < A_i + B_i \)

When the revenue of fines obtained by the government is greater than the expenses paid for supervision, the benefits of the company’s non-performance of social responsibility are higher than the benefits of the company’s social responsibility, but the difference between the two is less than the government’s reward for performing social responsibility and the government’s non-performance of social responsibility. When the sum of fines of an enterprise meets the condition of \( 0 \leq \frac{R_2 - R_1}{A_i + B_i} \leq 1 \), the
evolutionary game model has the following five equilibrium points: (0, 0), (0, 1), (1, 0), (1, 1), \( \left( \frac{R_2-R_1}{A_1+B_1}, \frac{B_1-C_2}{A_1+B_1} \right) \). Calculate det J and trace J of each equilibrium point, the results are shown in Table 4.

**Table 4** Stability analysis when government supervision costs are low and companies generally fulfill their social responsibilities

| LEP | det J | Results |
|-----|------|---------|
| (0, 0) | \((B_1-C_2)(R_1-R_2)\) | - Saddle point |
| trace J | \((B_1-C_2)+(R_1-R_2)\) | - Saddle point |
| (0, 1) | \((A_1+C_1)(R_1-R_2)\) | - Saddle point |
| trace J | \(-(A_1+C_1)-(R_1-R_2)\) | - Saddle point |
| (1, 0) | \(-(B_1-C_2)((A_1+B_2)+(R_1-R_2))\) | - Saddle point |
| trace J | \(-(B_1-C_2)+[(A_1+B_2)+(R_1-R_2)]\) | - Saddle point |
| (1, 1) | \(-(A_1+C_1)((R_1-R_2)+(A_1+B_2))\) | - Saddle point |
| trace J | \((R_1-R_2)-(B_1-C_2)\) | + Central point |

It can be seen from Table 4 that when the cost of government supervision is low, and companies generally perform social responsibilities, there is no equilibrium point, and there is a central point \( \left( \frac{R_2-R_1}{A_1+B_1}, \frac{B_1-C_2}{A_1+B_1} \right) \). This shows that the government and enterprises have chosen a mixed strategy, that is, the government carries out a certain degree of supervision, and enterprises also fulfill part of their social responsibilities. In the beginning, the government only needs to pay a small number of supervision fees, so the government can get more benefits, so it chooses the supervision strategy, and the company will choose to fulfill its social responsibilities to save expenditure. However, the enterprise’s fulfillment of social responsibilities will lead to the government More bonuses need to be paid. Considering this, the government will choose not to supervise the enterprise. Because there is no pressure from government supervision, the enterprise has given up protecting the environment. At this time, the government’s supervision cost is reduced, and the government will re-supervise. In the end, the government and the enterprise will obtain a mixed strategy through repeated iterations, that is, the government carries out a certain degree of supervision, and the enterprise also fulfills part of its social responsibilities. At this time, the government and the enterprise will have the greatest benefits.

(3) \( B_1 > C_1, R_2 - R_1 < 0 \)

In the case that the fine income obtained by the government is greater than the cost of supervision, and the enterprise’s non-performance of social responsibility benefits is lower, the condition \( 0 \leq \frac{R_2-R_1}{A_1+B_1} \leq 1 \) is not met, so the evolutionary game model exists as follows: Equilibrium points: (0, 0), (0, 1), (1, 0), (1, 1). Calculate det J and trace J of each equilibrium point, the results are shown in Table 5.
Table 5 Stability analysis under the condition of lower government supervision cost and more corporate social responsibility

| LEP         | det J                                | Results       |
|-------------|--------------------------------------|---------------|
| (0, 0)      | $(B_1 - C_1)(R_2 - R_2)$              | + Unstable    |
| trace J     | $(B_1 - C_1) + (R_1 - R_2)$           |               |
| (0, 1)      | $(A_1 + C_1)(R_4 - R_2)$              | + ESS         |
| trace J     | $-(A_1 + C_1) - (R_1 - R_2)$          | -             |
| (1, 0)      | $-(B_1 - C_1) [(A_1 + B_1) + (R_4 - R_2)]$ | - Saddle point |
| trace J     | $-(B_1 - C_1) + [(A_1 + B_1) + (R_4 - R_2)]$ |               |
| (1, 1)      | $-(A_1 + C_1) [(R_1 - R_2) + (A_1 + B_1)]$ | - Saddle point |
| trace J     | $(R_1 - R_2) - (B_1 - C_1)$           |               |

It can be seen from Table 5 that when the government supervision cost is low and the company fulfills more social responsibilities, the equilibrium point is (0,1). Because the fines imposed by the government on non-performance of social responsibility are higher than the government's supervision costs, the government's enthusiasm for supervision is not great. Besides, because the enterprise's non-performance of social responsibility has lower returns, to obtain the most profit, the enterprise will spontaneously During the production, environmental protection actions are taken. At this time, regardless of whether the government is not supervising, the enterprise will fulfill its social responsibilities, and government supervision still needs to pay costs and bonuses, so the government chooses not to supervise strategies. \[ (4) \ B_1 < C_1, \ R_2 - B_1 > A_1 + R_1 \]

In the case where the fine income obtained by the government is lower than the regulatory fee, the sum of the enterprise's income $R_1$ and the government's reward to the enterprise is less than the enterprise's income $R_2$, minus the fine imposed by the government, and does not satisfy $0 \leq \frac{R_2 - B_1}{A_1 + B_1} \leq 1$, so the evolutionary game model exists as follows: Equilibrium points: (0, 0), (0, 1), (1, 0), (1, 1). Calculate det J and trace J of each equilibrium point, the results are shown in Table 6.

Table 6 Stability analysis in the case of lower government supervision costs and less corporate social responsibility

| LEP         | det J                                | Results       |
|-------------|--------------------------------------|---------------|
| (0, 0)      | $(B_1 - C_1)(R_1 - R_2)$              | + ESS         |
| trace J     | $(B_1 - C_1) + (R_1 - R_2)$           |               |
| (0, 1)      | $(A_1 + C_1)(R_4 - R_2)$              | - Saddle point |
| trace J     | $-(A_1 + C_1) - (R_1 - R_2)$          |               |
| (1, 0)      | $-(B_1 - C_1) [(A_1 + B_1) + (R_4 - R_2)]$ | - Saddle point |
| trace J     | $-(B_1 - C_1) + [(A_1 + B_1) + (R_4 - R_2)]$ |               |
| (1, 1)      | $-(A_1 + C_1) [(R_1 - R_2) + (A_1 + B_1)]$ | + Unstable    |
| trace J     | $(R_1 - R_2) - (B_1 - C_1)$           |               |

We can see from Table 6 that when the government supervision cost is high and the company performs less social responsibility, the equilibrium point is (0,0). Due to the high cost of government supervision, the fines imposed by the government for non-performance of social responsibility are lower than the supervision costs. The government tends to avoid disadvantages and has no enthusiasm for supervision, so the government chooses not to supervise to save costs. In the case where the enterprise fulfills its social responsibilities, the enterprise's failure to perform its social responsibilities yields higher returns. To maximize the benefits, the enterprise also chooses not to perform its social responsibilities.

\[ (5) B_1 < C_1, \ 0 < R_2 - R_1 < A_1 + B_1 \]
In the case where the revenue of fines obtained by the government is lower than the regulatory fees, and the benefits of non-performance of corporate social responsibility are higher, the difference between the two is less than the government’s reward for performing social responsibility and the government’s fine for non-performing social responsibility. At the time of sum, the condition of \(0 \leq \frac{B_2 - C_1}{A_2 + B_2} \leq 1\) is not satisfied, calculate det \(J\) and trace \(J\) of each equilibrium point, the results are shown in Table 7.

### Table 7. Stability analysis under the condition that government supervision costs are high and enterprises generally fulfill their social responsibilities

| LEP | det \(J\) | Results |
|-----|---------|--------|
| (0, 0) | \((B_1 - C_1)(R_1 - R_2)\) | + ESS |
| trace \(J\) | \((B_1 - C_1) + (R_1 - R_2)\) | − Saddle point |
| (0, 1) | \((A_1 + C_1)(R_1 - R_2)\) | − |
| trace \(J\) | \(-(A_1 + C_1) - (R_1 - R_2)\) | − |
| (1, 0) | \(-(B_1 - C_1)[(A_1 + B_1) + (R_1 - R_2)]\) | + Unstable |
| trace \(J\) | \(-(B_1 - C_1) + [(A_1 + B_1) + (R_1 - R_2)]\) | + |
| (1, 1) | \(-[A_1 + C_1][R_1 - R_2] + (A_1 + B_1)\) | + Unstable |

From Table 7, we can see that there is an equilibrium point (0,0) when government supervision costs are high and companies generally perform social responsibilities. Due to the high cost of government supervision, the fines imposed by the government for non-performance of social responsibilities by enterprises are lower than the cost of supervision, and the enthusiasm for government supervision has declined, so they chose not to supervise. Moreover, the company found that it can get the maximum benefit without protecting the environment, so the company does not fulfill its social responsibilities.

(6) \(B_1 < C_1, R_2 - R_1 < 0\)

In the case where the fine income obtained by the government is lower than the supervision fee, and the enterprise’s non-performance of social responsibility benefits is low, the condition \(0 \leq \frac{B_2 - R_1}{A_1 + B_2} \leq 1\) is not satisfied, so the evolutionary game model exists as follows. The four equilibrium points yield the results shown in Table 8.

### Table 8. Stability analysis in the case of lower government supervision costs and more corporate social responsibility

| LEP | det \(J\) | Results |
|-----|---------|--------|
| (0, 0) | \((B_1 - C_1)(R_1 - R_2)\) | − Saddle point |
| trace \(J\) | \((B_1 - C_1) + (R_1 - R_2)\) | + ESS |
| (0, 1) | \((A_1 + C_1)(R_1 - R_2)\) | + |
| trace \(J\) | \(-(A_1 + C_1) - (R_1 - R_2)\) | − |
| (1, 0) | \(-(B_1 - C_1)[(A_1 + B_1) + (R_1 - R_2)]\) | + Unstable |
| trace \(J\) | \(-(B_1 - C_1) + [(A_1 + B_1) + (R_1 - R_2)]\) | + |
| (1, 1) | \(-[A_1 + C_1][R_1 - R_2] + (A_1 + B_1)\) | + Unstable |

| trace \(J\) | \((R_1 - R_2) - (B_1 - C_1)\) | − |

It can be seen from Table 8 that when the government supervision cost is high and the company fulfills more social responsibilities, the equilibrium point is (0,1). When the government's supervision...
cost is higher than the fines received, the government would rather abandon the fine income and the enthusiasm for supervision declines. At this time, the enterprise will perform its social responsibilities spontaneously because the enterprise's environmental protection responsibility is more profitable. Instead of getting a fine, on the contrary, you need to pay rewards for companies to fulfill their social responsibilities, so the government chose not to supervise.

To sum up, the difference in government supervision costs will affect the corporate behavioral choice of fulfilling social responsibility and technological innovation. Regardless of the government's regulatory choices or the choice of enterprises to fulfill their social responsibilities based on technological innovation, it is necessary to comprehensively consider the government's fine income, regulatory costs, and corporate income.

3. Simulation

According to the replication dynamic equations (3) and (4), the simulation results of the model can be calculated. Among them, the values of the probability $p$ of government supervision and the probability $q$ of enterprises taking environmental responsibility are $(0.1, 0.9)$, $(0.3, 0.7)$ $(0.5, 0.5)$ $(0.7, 0.3)$ and $(0.9, 0.1)$, respectively, projected It is the vertical axis and horizontal axis in the simulation graph. Next, this article will make different assignments to $B_1$, $C_1$, $R_2$, $R_1$, $A_1$ to undertake the research content in Chapter 2, and to assign values to government supervision costs, corporate social responsibility profits, non-performance penalty, etc., to study these variables. The impact on government regulation and the choice of companies to fulfill their social responsibilities.

1. When $B_1 > C_1$, $R_2 - R_1 > A_1 + B_1$, choice $B_1 = 3$, $C_1 = 2.5$, $R_2 = 12$, $R_1 = 4$, $A_1 = 3$. The simulation results are shown in Figure 1. No matter how much social responsibility the company performs in the beginning, and how much supervision the government performs, the enterprise will find that it does not perform its social responsibilities, and the gains obtained are higher than those obtained from the fulfillment of social responsibilities. The government finds that the regulatory gains are greater than the unregulated gains, so the government tends to Under supervision, enterprises tend to fail to fulfill their social responsibilities, and eventually get a balance at (1, 0).

2. When $B_1 > C_1$, $0 < R_2 - R_1 < A_1 + B_1$, choice $B_1 = 3$, $C_1 = 2.5$, $R_2 = 8$, $R_1 = 4$, $A_1 = 3$. At this time, there is no equilibrium point, there is a center point $(0.667, 0.083)$, the simulation results are shown in Figure 2. When the cost of government supervision is low, and there are generally many enterprises performing social responsibilities, there is no equilibrium point. The government will choose supervision at the beginning considering the lower supervision cost, and enterprises will reduce the cost of fines caused by government supervision. Will perform social responsibilities, but at the same time, the government will need to invest more manpower and material resources to investigate and estimate, so the cost of supervision increases, not only need to pay incentives to the enterprise but also lose the fine income for the company not to perform social responsibilities, consider this, The government will choose not to supervise the enterprise. Because there is no pressure from government supervision, the enterprise will no longer fulfill its social responsibility. At this time, the government's supervision cost will be reduced, and the government will re-supervise. This will be repeated, and the government and enterprises will continue to cycle. The company obtained a mixed strategy, that is, the central point $(0.667, 0.083)$, the government carried out a certain degree of supervision, and the company also fulfilled a certain degree of social responsibility. Under this strategy, both the government and enterprises can obtain the most beneficial benefits for themselves.

3. When $B_1 > C_1$, $R_2 - R_1 < 0$, choice $B_1 = 3$, $C_1 = 2.5$, $R_2 = 12$, $R_1 = 4$, $A_1 = 3$. There is an equilibrium point $(0, 1)$, and the simulation results are shown in Figure 3. When government fines are higher than the government’s supervision costs, and the profits of the company are higher when the company does not fulfill its social responsibilities, to maximize their respective benefits, regardless of the behavior of the government and the company at the beginning, the company will Actively choose to perform social responsibilities to obtain more benefits, and so is the government, so in the end, it will soon be balanced at $(0, 1)$, that is, the government does not supervise and companies perform social responsibilities.
(4) When $B_1 < C_1$, $R_2 - R_1 > A_1 + B_1$, choice $B_1 = 3$, $C_1 = 5$, $R_2 = 12$, $R_1 = 4$, $A_1 = 3$. The results are shown in Figure 4. When the cost of government supervision is too high, and the benefits obtained by companies failing to fulfill their social responsibilities are greater than the sum of the rewards obtained by the government and fulfilling their social responsibilities, regardless of the strategies of the two parties at the beginning, they will choose strategies that are beneficial to them, so the government will choose not to supervise, companies will choose not to fulfill social responsibilities, the final equilibrium point is (0,0).

(5) When $B_1 < C_1$, $0 < R_2 - R_1 < A_1 + B_1$. Choice $B_1 = 3$, $C_1 = 5$, $R_2 = 8$, $R_1 = 4$, $A_1 = 3$, there is an equilibrium point (0,0), the result is shown in Figure 5. When the government fine is lower than the regulatory cost paid by the government, and the profit of the enterprise is higher when the enterprise fulfills its social responsibility, but the sum of the proceeds of the enterprise’s non-performance of social responsibility and the government fine is smaller, the government is responsible for the regulatory cost. The excessive choice is not to supervise, because the government does not supervise, the enterprise cannot get the reward money and will not be punished. At this time, the enterprise does not fulfill its social responsibilities, the profit is higher, so the enterprise is more inclined not to take responsibility.

(6) When $B_1 < C_1$, $R_2 - R_1 < 0$. Choice $B_1 = 3$, $C_1 = 5$, $R_2 = 8$, $R_1 = 12$, $A_1 = 3$, there is an equilibrium point (0,1), and the simulation results are shown in Figure 6. When the government's regulatory cost is higher than the income obtained from the fine, the enthusiasm of the government's supervision will decline. At this time, because the enterprise’s social-environmental responsibility is more profitable, the enterprise will spontaneously carry out green technology innovation to assume its social responsibility, government supervision will not receive a fine. On the contrary, it will need to pay rewards to enterprises to fulfill their social responsibilities, so the government chooses not to supervise.

![Figure 1: Lower government supervision costs and less corporate social responsibility](image1)

![Figure 2: Lower government supervision costs and more corporate social responsibility](image2)
Figure 3: Lower government supervision costs and more corporate social responsibility

Figure 4: Lower government supervision costs and less corporate social responsibility

Figure 5: Higher government supervision costs and more corporate social responsibility
According to different situations, $B_1$, $C_1$, $R_2$, $R_4$, $A_4$ are assigned different values, and $p$ and $q$ are taken in five groups. Through numerical simulation, the equilibrium points corresponding to different $p$ and $q$ values are reflected. The simulation results corroborate the analysis results of the theoretical model that there is no fixed connection between whether the government supervises and whether the company fulfills its social responsibilities. The different benefits obtained, as well as changes in various factors such as bonus income and penalty costs arising from whether the company performs social responsibilities, government regulatory choices and corporate social responsibility choices will change. Therefore, if the company is required to perform social responsibilities to carry out green technology innovation, we first need to reduce the government's supervision costs, to increase the enthusiasm of government supervision. If the government has enthusiasm, then it will urge enterprises to pay attention to their social responsibilities. Second, we must increase the state's support for enterprises, and find ways to reduce the cost of corporate social responsibility.

4. Conclusions
This paper uses the evolutionary game model to build an evolutionary game model of social environmental responsibility of energy enterprise under the condition of green technology innovation, to explore the government and business strategy choices in the case of the different government costs and different business benefits. First of all, the strategic choice based on corporate environmental responsibility must be green innovation, and to maximize corporate benefits, it is necessary to find a balance between social environmental responsibility of energy enterprise and government supervision. Secondly, whether the government supervises the energy enterprise and whether the energy enterprise will fulfill its social responsibilities depends on the specific circumstances. It needs to comprehensively consider the government cost, the different benefits that the energy enterprise receives in different situations, as well as changes in various factors such as bonus income and penalty costs arising from whether the company fulfills its social environmental responsibilities.

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