Research of the Behavior of Low-Carbon Economy Subjects Based on Incentive Compatibility Theory

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Abstract. The development of low carbon economy is closely related to the interests of all sectors of society, especially the main three to participate: the government, enterprises and the public. In this process, how to coordinate the interests of all parties and formulate a reasonable incentive mechanism has become an important task for the government. Studied on the analysis of the behavior status and goals of the government, enterprises and public on the background of low carbon economic development, then used the game method to quantify each object’ interests of the target and relations. At last, designed incentive mechanism on the basis of incentive compatibility principle to meet the individual subject welfare maximization and, the greatest degree of protection for the development of low carbon economy.

Introduction

Low-Carbon economy is a kind of economic form of low carbon development, low-carbon industry, low-carbon technology, low-carbon life and so on. Analysis of the current stage of the impact of the low carbon economy can be found: China's low carbon economy development not only requires the government to enact relevant laws and regulations, to guide the industrial structure adjustment and economic growth mode change, but also need to reduce energy consumption and environmental pollution from their own business\(^1\); In addition to the change of consumer structure and the cultivation of low carbon concept, and the supervision of nongovernmental organizations and the influence of government legislation on the development of low carbon economy also have an important role in promoting. Therefore, the low carbon economy related subject can be divided into government, enterprise, consumer three. In the determination of the low carbon economy, according to the three main body of the status and interests, the use of the game theory analysis can draw the low carbon economy of the three main related body of the objective function and gain matrix\(^2\), can according to the "incentive compatibility" principle research formulation can make all the interests of the incentive mechanism to promote and improve their behavior, so as to promote the development of low carbon economy.

Binary Game Analysis between Government and Enterprises in Low Carbon Economy

The Premise of the Game Analysis between Government and Enterprises

(i)The game model is divided into two stages: short term and long term. In the short term, the government and enterprises in the initial economic benefits of developing low carbon economy are G and E respectively.

(ii) In the short term, the government will pay subsidies to encourage enterprises to develop low-carbon economy, but in the long term due to the low carbon economy has developed mature, the government will no longer grant subsidies to S. At the same time, if the enterprise does not develop low-carbon economy and lead to deterioration of environmental pollution, the government in order to control environmental costs Cg, and enterprises in the long term will be subject to a fine of F.

(iii) In order to develop a low carbon economy, enterprises must pay a one-time payment of economic costs Cc. But at this point, the government will receive S (S<Cc), but due to the low carbon products are not popular, the economic benefits of enterprises will be reduced to aE (0<a<1).
(iv) If the government develops a low carbon economy, it will get social benefits (public political votes) and good international reputation and other external benefits Ig. In contrast, the government will lose the external benefits Ig of the above, if not the development of low-carbon economy.

(v) If an enterprise develops low carbon economy, it will get the external benefits Ic of enterprise value and international competitiveness. if not, the enterprise will lose the external benefits Ic.

(vi) The economic benefits of enterprise is fully reflected in the second stage, if the enterprise development low-carbon economy, due to the market demand for low carbon products, will get economic benefits bE (b>1); if the enterprise does not develop, then, will lose the market competitiveness in the second stage, the economic benefits of the enterprise is only cE (0<c<a<1).

(vii) The revenue function of the government and enterprises in this model is both two stages plus.

(viii) The construction of this model is based on the assumption that the information is full, and does not consider the impact of discount rate and interest rate.

Based on the above basic assumption, the establishment of the government and enterprises on the two sides of the game model is as follows:

<table>
<thead>
<tr>
<th>Government</th>
<th>Development</th>
<th>Not development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise</td>
<td>Development</td>
<td>Not development</td>
</tr>
<tr>
<td>Development</td>
<td>(aE+S+Ic-Cc)+(bE+Ic), (G+Ig+S)+(G+Ig)</td>
<td>(aE+Ic-Cc)+(cE+Ic), (G-Ig)+(G-Ig)</td>
</tr>
<tr>
<td>Not development</td>
<td>E+(cE-F-Ic), (G+Ig-Cg)+(G+F+Ig-Gg)</td>
<td>E+(cE-Ic), (G-Ig-Cg)+(G-Ig-Cg)</td>
</tr>
</tbody>
</table>

The Game Analysis between Enterprise and Government’s Selection Strategy

Following the equilibrium condition of the model analysis, assumed PI ij denote enterprises to choose the strategies I, J strategy the government chooses of profit; sigma ij respectively enterprises to choose the strategies I, when the government choose J strategy, government revenue. At this point can be divided into four cases, respectively.

(i) When the government chooses to develop low-carbon economy, the benefits of enterprise development and the development of low carbon economy are:

$$\pi_{11}=(aE+S+Ic-Cc)+(bE+Ic).$$  \hspace{1cm} (1)

$$\pi_{21}=E+(cE-F-Ic).$$  \hspace{1cm} (2)

Make \(\Delta_1=\pi_{11}-\pi_{21}= (a+b-1-c)E+S+3Ic+F-Cc.\) \hspace{1cm} (3)

Make \(\Delta_1>0\), namely \((a+b-1-c)E+S+3Ic+F-Cc>Cc.\) \hspace{1cm} (4)

\(\Delta_1\) indicates that enterprises to develop low carbon economy and the development of low carbon economy income difference, when the difference is greater than zero, as a rational economic person of the enterprise will have power the development of low carbon economy. From the upper type, we can know: first, from the 0 << a < 1 < b obtained (a + c) + (b -1)> 0, said the company's development of low-carbon economy, the sum of the economic benefits of the two will be greater than the sum of the economic development. The difference between the sum of the economic benefits of the two periods, the enterprise development of low-carbon economy will be stronger; Second, the opportunity cost of enterprise carbon emissions is reflected by the government subsidies S and the government to punish F. The higher the government subsidies, the higher the total income of the enterprise developing low carbon economy, the higher the government punish F, the lower the total income of the enterprise development of low carbon economic losses. Third, social benefit is one of the driving forces of enterprise to develop low carbon economy. The external benefits such as enterprise value and international competitiveness are mainly from the public for the public for the low carbon production of enterprises and the social from all walks of
life for the sustainable development of the sense of identity. Fourth, this is also the most intuitive one factor, enterprise engaged in the low carbon economy to pay the economic cost of Cc, then the enterprise to participate in low carbon production will be weak.

(ii) When the government does not choose to develop low-carbon economy, the benefits of enterprise development and the development of low carbon economy are:

$$\pi_{12} = (aE+Ic-Cc)+(bE+Ic).$$  \tag{5}

$$\pi_{21} = E+(cE-Ic).$$  \tag{6}

Make $\Delta_2 = \pi_{12} - \pi_{22} = (a+b-1-c)E+S+3Ic-Cc.$  \tag{7}

The key factors from $\Delta_2$ shows, when government chooses not to the development of low carbon economy, the enterprise choice consciously developing low carbon economy and not only the economic interests of enterprises difference $(a+b-1-c)E$, public and social awareness of low-carbon IC, and enterprises to develop low carbon economy the need payment the economic cost of CC. The greater the difference of economic interest $(a+b-1-c)$ is, the higher the willingness to participate in low carbon production; the higher the public and society's low carbon consciousness $Ic$, the higher the enterprise is engaged in the low carbon production; the higher the economic cost of enterprises to develop low-carbon economy, the weaker the power of enterprise development.

(iii) When the enterprise chooses to develop low-carbon economy, the government's development and the benefits of the development of low carbon economy are:

$$\varphi_{11} = (G+Ig-S ) +(G+Ig).$$  \tag{8}

$$\varphi_{12} = (G-Ig)+(G-Ig).$$  \tag{9}

Make $\Delta_3 = \varphi_{11} - \varphi_{12} = 4Ig-S.$  \tag{10}

When the enterprise chooses to develop low-carbon economy, the government's development of low carbon economy depends mainly on two factors: on the one hand, the social benefit and good international reputation and other external benefits;on the other hand, the government's development of low carbon economy is also the key factor to decide whether the choice or not.

(iv) When an enterprise chooses not to develop low-carbon economy, the government's development and the benefits of the development of low carbon economy are:

$$\Phi_{21} = (G+Ig-Cg ) +(G+F+Ig-Cg).$$  \tag{11}

$$\Phi_{22} = (G-Ig-Cg)+(G-Ig-Cg).$$  \tag{12}

Make $\Delta_4 = \varphi_{21} - \varphi_{22} = 4Ig+F.$  \tag{13}

Obviously, $\Delta_4 > 0$ is set up, which indicates that the government will implement the low-carbon economy when the enterprise does not develop low-carbon economy. This is mainly because when the firm does not undertake the responsibility of environmental protection, as a subject of public management, in order to increase the social welfare, government can only single bear low carbon economic development, improve the heavy responsibility of the quality of the environment.

The Tripartite Game Analysis after Join the Public

The government and enterprises are discussed in the development of low carbon economy equilibrium conditions, but the development of low-carbon economy is not only the government and enterprises can be achieved by the two main body, it is also the same as the public (including environmental protection organization) efforts$^{[4]}$. Therefore, the game process and results of the government and enterprises under the public participation are analyzed.
Model Assumptions of the Game Model Based on Complete Information

(i) Game model total government, business and the public tripartite stakeholders, the three are rational economic man, the government is pursuing the maximization of social welfare, enterprises and the public are seeking to maximize their own interests;

(ii) The government, enterprise and public policy options are \{participation, not participating\};

(iii) The three bodies interest in the case of an initial non-participation were: \(\pi_1\), \(\pi_2\), \(\pi_3\);

(iv) The absence of government and business are involved, the government will give subsidies to S. enterprise economy. But at this point, if the public participation in the case, the enterprise is not involved, the enterprise will lead to environmental degradation and by the government's punishment. The punishment is not fixed, and the number of public reports is positively related to the nF said, where F is the base of the penalty, n is the number of people reported, and the public because of the pollution behavior of enterprises will be rewarded E. But if the government does not participate, even if the public to report, the government will not be punished for the enterprise.

(v) In the case of enterprise participation, the introduction of technology development and the updating of the equipment need to be invested in capital \(C_1\). In addition, public participation due to the need to invest time and energy to review whether the enterprise has the pollution, but also to buy the corresponding test equipment. Thus, we assume that the cost of public participation is \(C_2\).

(vi) If the enterprise carries out low carbon production, it will reduce the pollution of the environment, bring positive externalities, including the increase of social welfare \(I_g\), enhance corporate image \(I_c\) and improve the quality of life of the public \(I_c\).

The Tripartite Game Analysis among Government, Enterprises and Public

In real life, because the government information is public, so the government to participate in low carbon economy development or not is to know\(^5\). The decision-making behavior of enterprises and the public is unknown, so we can be divided into the following two kinds of situations:

(i) Analysis of the game between government and public when the government is not involved.

Table 2. Analysis of the game between the government and the public.

<table>
<thead>
<tr>
<th>Public</th>
<th>Enterprise</th>
<th>Does not participate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>participate</td>
<td>(\pi_3-C_2+I_c) ,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\pi_2-C_1+I_c)</td>
</tr>
<tr>
<td></td>
<td>Does not participate</td>
<td>(\pi_3-C_2-I_c) ,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\pi_2-I_c)</td>
</tr>
<tr>
<td></td>
<td>Does not</td>
<td>(\pi_3+I_c) ,</td>
</tr>
<tr>
<td></td>
<td>participate</td>
<td>(\pi_2-C_1+I_c)</td>
</tr>
<tr>
<td></td>
<td>Does not participate</td>
<td>(\pi_3-I_c) ,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\pi_2-I_c)</td>
</tr>
</tbody>
</table>

The game matrix shows that the government does not participate in the game matrix of the enterprise and the public, it can be seen: On the one hand, \(\pi_3-C_2+I_c<\pi_3+I_c\), \(\pi_3-C_2-I_c<\pi_3-I_c\) seen, whether companies choose to participate or not to participate in the development of low-carbon economy, the public would choose not to participate; On the other hand, by the equation \(\Delta=(\pi_2-C_1+I_c)-(\pi_2-I_c)=2I_c-C_c\). Whether the government is not involved in the case, whether the enterprise participation in low carbon economy development, and whether the public participation, and mainly based on participation in low carbon economy can bring social benefits can be greater than the development of low carbon economy, if the social benefits will be greater than expenses, then the enterprise will participate, and vice versa will not participate.

(ii) Game analysis between government and enterprises and the public
### Table 3. Game analysis between government and enterprises and the public.

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Does not participate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participate</td>
<td>( \pi_{3-C2+Ic} ), ( \pi_{2+S-C1+Ic} )</td>
</tr>
<tr>
<td>Does not participate</td>
<td>( \pi_{3+Ic} ), ( \pi_{2+S-C1+Ic} )</td>
</tr>
</tbody>
</table>

The following game matrix shows that the government is involved in the game matrix between enterprises and the public, from which we can know: First, when the enterprises to participate in, by \( \pi_{3-C2+Ic} < \pi_{3+Ic} \), the public to understand enterprises have been involved in the development of low carbon economy and for environmental pollution control; Second, when the enterprises do not participate in, by \( \Delta = (\pi_{3-C2+E-Ic}) - (\pi_{3-Ic}) = E-C2 \) know, at this time as a rational economic agents and the public will give consideration of the government of the reward, and their supervision of enterprises to pay the cost of \( C2 \) size, if give the government the reporting incentives e greater than their supervision of firms that pay cost \( C2 \), then the public will choose to participate in, otherwise it will elect not to participate. Third, but the public choose to participate, \( \Delta = (\pi_{2+S-C1+Ic}) - (\pi_{2-nF-Ic}) \) = \( S+2Ic+nF-C1 \) then decided to enterprises in low carbon economic development factors there are four: government subsidy, government fines, social benefits and to participate in the development of low carbon economy are required to pay into the, the sum of only the current three to greater than the last item of expenditure, enterprises will be in low carbon economy development; But the public chose not to participate in, known by \( \Delta = (\pi_{2+S-C1+Ic}) - (\pi_{2-Ic}) \), because there is no public participation, corporate environmental pollution behavior will not disclosed and government have no way to the enterprise fine.

### Summary

In this paper, the government, enterprises, public three main body in their respective interests and behavior goals, combined with the game analysis to study the interests of the three objectives of the relationship, so the government's point of view, by coordinating the interests of enterprises and the public, can develop a low carbon economy incentive compatibility principle.

The government should fully mobilize the enthusiasm of enterprises to develop low carbon economy. Use economic measures such as subsidies, penalties, tax and other measures to increase support for enterprises, and guide enterprises to develop new technologies to reduce the cost of economic costs to engage in low carbon production, and promote the formation of a long-term mechanism for low carbon production enterprises\(^6\). The government should promote public to play an important role in the development of low carbon economy. The government should encourage and promote the public to carry out low-carbon lifestyle, so that the concept of low carbon really popular\(^7\). Let the public to protect and save energy through the purchase behavior of the public, thereby affecting the enterprise's production decisions. To sum up, to give full play to the guiding role of government, to provide a good policy and public opinion environment for enterprises and the public, establish a the active participation of the whole society, the main body of common development, mutual coordination of all aspects of low carbon economic incentive mechanism.
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References