2011 International Conference on Information Management and Engineering (ICIME 2011)
IPCSIT vol. 52 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCSIT.2012.V52.66

Game Analysis of Corporate Behavior and Government Regulation on Carbon Reduction

Lu Xiao-qi

Jiangxi University of Finance and Economics, Department of Tax and Public Management
Nanchang, China

Abstract—The external economic activity which needs government's intervention and guidance exists in the behavior of corporate carbon emission reduction. However, the consistency of interests between enterprises and government departments leads to invalid regulation of the government in carbon emissions reduction. In this paper, we analyze the process of supervision and guide behavior of the government in carbon emission reduction and we analyze the decision-making process of corporate in carbon emission reduction behavior, and get the game results from the perspective of game theory. On this basis, we conclude that reducing carbon emissions, increasing the amount of fines for the companies with high carbon emission, reducing tax for the business who do good performance in carbon emission reduction, and improving the regulation efficiency of the government can increase the probability of the enterprises on reducing carbon emissions.

Keywords-carbon reduction actions; government regulation; game analysis

1. Introduction

According to the Intergovernmental Panel on Climate Change's latest assessment of climate change, in the past 100 years, the global average surface temperature has risen by a 0.6 ℃ 0.3 ℃, which caused by the carbon dioxide and other greenhouse gases. And it is believed with 90% confidence that the climate's change in nearly 50 years mainly caused by anthropogenic emissions of carbon dioxide, methane, nitrous oxide and other greenhouse gases. The global warming which caused by atmospheric carbon dioxide (CO_2) concentration challenges human survival and development. In response to global warming that caused challenges to human survival and development, western developed countries such as Britain proposed developing of low-carbon economy, which emphasizes the maximum reduction of carbon emissions on industrial development, economic growth and consumption patterns, and requires taking conservation of energy resources and ecological protection. September 8, 2007, President Hu Jintao gave a speech in the fifteenth APEC informal leadership meeting and put forward to four special proposals specifically on how countries to deal with global climate change together, which refers to four "C": "developing low-carbon economy", taking R & D and promotion of "low-carbon energy technologies", "Increasing carbon sinks", and "Promoting carbon sequestration technology". At present, carbon emissions mainly come from the energy and materials which have been consumed in the production process by the enterprise. Therefore, it is necessary for government as the supervisor of the social system to take the supervision and guidance to the carbon reduction behavior of the enterprises. The government can adjust, monitor and guide the carbon reduction activities of enterprises by formulating policies and developing tax incentives, in order to maintain the coordination between the environment and economic or social development.

However, Companies with high carbon emissions have close interaction with the local government. On the one hand, the enterprises' development need government support, for example, the founder of the enterprise need the government's approval, and many enterprises require government guarantees for loans. On the other hand, government can help the enterprise to solve the employment problem of rural surplus labor, increase government revenue, achieve economic growth, and improve the performance of government

E-mail address: Luxiaoqi12345@163.com

officials. So, we can say that the government and business are interdependent and indivisible to some extent. The interests of consistency between the government and business lead to protectionism and ineffectively regulation in carbon reduction, which lead to the enterprises lacking of external constraints, only to maximize the interests and minimize the cost. Fianlly carbon reduction behavior becomes a mere formality. At present, the large amounts of carbon emission from the business cause serious environmental pollution, which become an extremely serious problem. So, it is urgent for us to find ways to reduce the carbon emissions.

In this paper, we first study the decision-making process between government regulation of carbon emissions and carbon reduction behavior of corporate from the perspective of game theory, then, we get the conclusion and give the suggestion that the government should strengthen the supervision and take guidance to the corporate's behavior of carbon reduction, and encourage the corporate to reduce carbon emissions.

2. Game Model and Analysis

2.1. Game Model

Static game is that in the game, the participants make strategy at the same time or not at the same time, but the latter did not know which concrete action principles the first actors will take. The game between government departments and enterprises will form a complete information game static game model.

Assumptions: the government adopts two strategies such as taking regulatory or taking no supervision, provide no tax support to enterprises with high-carbon emissions, and know companies will implement carbon reduction mandate or not implement the mandate. Business income R. Companies have to pay taxes to the government at tax rate t, whether it perform the task of carbon reduction or not. Government who take the administrative action, economic or legal means to the companies with high carbon emission will cause the regulating cost c_1. The probability of taking regulatory is α. If the business comply with regulatory completely and cooperate with the government's regulatory to reduce carbon emissions, they will cause the cost c_2. (Here, we don't consider the revenue which received from the the good reputation by the enterprise for their compliance with government regulation, because this value is small in the environmental with low awareness in energy saving and carbon emission reduction.) The probability of the enterprise's compliance with regulatory is β. If the companies with high carbon emission will take non-compliance with government's regulation, only to pursue the short-term interests and continue to maintain high carbon emissions, they will be punished, and required to suspend production for rectification, then, the companies will cause the cost, and we assume the cost is c_3. At the same time, we suppose under the conditions that government will take the strict supervision in carbon reduction, the companies will be found as long as it remains high carbon emissions. If the government does not perform the supervision strictly, the enterprises will not comply with regulatory and the carbon emissions will still keep high, which will lead to climate change and deterioration of ecological environment. We assume that they will bring the external cost c_4 ($c_4 > c_3$).The costs c_4 will be paid by the government.

When government does not provide taxation policies support for the enterprise incarbon reduction, the game matrix between government departments and enterprises is as follows:

TABLE I. The Game Matrix When the Government Does Not Take the Responsibility for Negligent Supervision

Companies with High Carbon Emissions	**Government Departments**	
	Strict Implementation of Environmental Monitor(α)	***No Strict Implementation of Environmental Monitor(1-α)***
Comply with Carbon Reduction(β)	$(R-c_2)(1-t),(R-c_2)t-c_1$	$(R-c_2)(1-t),(R-c_2)t-c_1$
Not Comply with Carbon Reduction(1-β)	$R(1-t)-c_3,tR+c_3-c_1$	$R(1-t),tR$

2.2. Government Does not Take Responsibility for Negligent Supervision

From the companies with high carbon emissions point of view, if the government departments strictly enforce environmental regulations,the corporate decision-making depends on the size of $(R-c_2)(1-t)$ and $R(1-t)-c_3$. We assume that c_2/c_3 is greater than1-t, and it means that $R(1-t)-c_3$ is greater than $(R-c_2)(1-t)$, then,

corporate will not choose the strategy that comply with the regulatory. Assuming that the government does not implement the monitor of carbon reduction actions, the corporate will choose the strategy that not comply with regulatory. So, when c_2/c_3 is greater than(1-t), the dominant strategy for the companies with high carbon emissions is non-compliance with the rules of reducing carbon emissions. From the perspective of the government, we assume that enterprises with high carbon emissions comply with government regulation, the government departments will choose the strategy of no regulation in order to reduce the workload. When the enterprises with high carbon emissions do not comply with regulatory, the government's behavior will depend on the value of c_3-c_1. If (c_3-c_1)‹0, it means that the regulatory costs are higher than the amount of penalties (which is consistent with the reality), in this situation, the government departments will get less revenue. Then, the government will not choose the regulatory actions. Finally it forms a Nash equilibrium - no regulation, non-compliance.

Through above analysis, we can draw the conclusion that those enterprises with high carbon emissions, which driven by economic interests, will not reduce carbon emissions, and will try their best to save the cost that spend in carbon reduction before when they have been found by the government. Even if they have been found, the cost they saved is much greater than the fine they paid, they will have no loss. Therefore, more enterprise prefer pay a fine to avoid carbon reduction to spend the cost for carbon reduction. Many local government only take a symbolic fine of high carbon emitters in order to reduce the workload and regulatory costs, and maintain the source of fiscal revenue, as a result, the ineffective government regulation exists and the carbon emissions from the corporate are still high.

In the payment matrix, if $c_2/c_3<(1-t)$, pure strategy Nash equilibrium does not exist in the game. Then, we must solve the mixed strategy Nash equilibrium. The conditions that $c_2/c_3<(1-t)$ established are: one way is to decrease the value of c_2/c_3, decrease c_2 or increase c_3, the other way is to decrease the value of t, for reducing the cost of carbon reduction. Whether Increase the amount of fees for the companies with high carbon or lower taxes can make the condition of $c_2/c_3<(1-t)$established. At this point, the expectations income function of government and business are:

$$\Pi_g=\alpha\{\beta[(R-c_2)t-c_1]+(1-\beta)(tR+c_3-c_1)\}+(1-\alpha)[(R-c_2)t\beta+(1-\beta)tR] \quad (1)$$

$$\Pi_e=\beta[\alpha(R-c_2)(1-t)+(1-\alpha)(R-c_2)(1-t)]+(1-\beta)\{\alpha[R(1-t)-c_3]+(1-\alpha)R(1-t)\} \quad (2)$$

take the first order derivative to α and β in formula (1) and (2) respectively, we can get Nash equilibrium solutions as follows:

$$\alpha^*=(1-t)c_2/c_3, \quad \beta^*=1-c_1/c_3 \quad (3)$$

If the probability of government's monitor is less than α^*, The optimal strategy for the enterprises with high carbon emissions is no carbon reduction. Or, If the probability of government regulation is greater than α^*, the optimal strategy of the enterprise is compliance with monitor and reduce carbon. If the probability that the business of non-compliance with regulatory is less than β^*, the optimal strategy for the government is supervision.

In a word, In this game, Nash Equilibrium was related with the carbon reductioncosts of the companies with high carbon c_2, the penalty amount c_3, tax rate t the corporate paid. The lower the carbon reduction cost of corporate,the greater the intensity of punishment that the government gives to companies, the lower the tax rate the corporate paid, and the higher the probability of government regulation, the smaller the probability of the companies not comply with carbon emissions and regulation. The higher the cost of government regulation, and the lower the external costs of carbon emission, the less probability of the companies comply with the regulatory.

2.3. Government Takes Responsibility for Negligent Supervision

The above analysis of the optimal choice between business and government is based on which the government takes no responsibility for negligent supervision. As the reasons that the enterprises evade the responsibility of carbon reduction, and fail to comply with the provisions of reducing carbon emission are

mainly because of the government's negligence, the government should take the corresponding responsibility c_4.

TABLE II. GAME MATRIX WHEN THE GOVERNMENT TAKES RESPONSIBILITY FOR NEGLIGENT SUPERVISION

Companies with High Carbon Emissions	**Government Departments**	
	Strict Implementation of Environmental Monitor(α)	***No Strict Implementation of Environmental Monitor(1-α)***
Comply with Carbon Reduction(β)	$(R-c_2)(1-t),(R-c_2)t-c_1$	$(R-c_2)(1-t),(R-c_2)t$
not Comply with Carbon Reduction(1-β)	$R(1-t)-c_3,tR+c_3-c_1$	$R(1-t),tR-c_4$

Now, the expectations income function of government and business are as follows:

$$\Pi_g=\alpha\{\beta[(R-c_2)t-c_1]+(1-\beta)(tR+c_3-c_1)\}+(1-\alpha)[(R-c_2)t\beta+(1-\beta)(tR-c_4)] \quad (4)$$

$$\Pi_e=\beta[\alpha(R-c_2)(1-t)+(1-\alpha)(R-c_2)(1-t)]+(1-\beta)\{\alpha[R(1-t)-c_3]+(1-\alpha)R(1-t)\} \quad (5)$$

take the first derivative toα and β in equation(4) and (5) respectively, and we can arrive solution in mixed strategy Nash equilibrium:

$$\alpha^*=(1-t)c_2/c_3, \quad \beta^{**}=1-c_1/(c_3-c_4) \quad (6)$$

The results show that when $\beta^{**}>\beta^*$, the government takes responsibility for negligent supervision. This action from the government will bring about the positive effect, which can increase the probability of corporate carbon reduction.

3. Conclusion

In short, we can increase the probability of behavior that enterprises reduce carbon emissions by reducing the cost of carbon emission, increasing penalties for companies with high carbon emissions, cutting down the corporate tax rate, improving the efficiency of government regulation and increasing the responsibility of the government's negligent duty.

4. Suggestion

First, establish the performance evaluation mechanism of taking a green GDP or unit GDP energy consumption as an indicator, taking the level of carbon emissions, the level of energy efficiency, and living environment as a performance evaluation index to evaluate the local development or government officials, which can urge the government officials to firmly establish the consciousness of scientific development and monitor the corporate behavior of carbon reduction to promote economic and social to maintain sustainable development.

Second, strengthen penalty and prevent the companies who will add the costs to the product, or, it will bring about that the consumer pay for the external behaviors of the producers. Therefore, we should consider reducing tax rate of the corporate for encouraging carbon emissions. On one hand, we can help the producers reducing the production cost, reducing its burden on businesses and maintaining its profit unchanged after carbon reduction; On the other hand, it is necessary for the government to reduce their anticipation that revenue excessively rely on the business. Then we can improve the supervision initiative of the government to the carbon reduction actions.

Third, increase penalties for the dereliction of duty of government officials. The government should have the courage to take the responsibility for the external costs that caused by their poor supervision and management in regulatory process. Officials who are indifferent to companies' high carbon emissions within

their jurisdiction should be given severe administrative punishment. At the same time, the costs which have been used to control carbon pollution should be shared by the negligent person and her department. Only if should we take the gains and losses of monitoring behavior linked with their own interests, we can improve the efficiency of supervision.

5. Acknowledgement

Thank my teacher, Mr. Kuang Xiao-ping who gave me many suggestions. Thank my colleagues who gave me a lot of help in the course of my writing.

This project has been sponsored by the graduate self-innovation projects in Jiangxi Province, the project name is: how to use tax policy to encourage the development of low-carbon economy in underdeveloped cities--take NanChang as an example(YC10A077).

6. References

[1] Zhang wei-ying, Game Theory and Information Economics, Shanghai: Shanghai People's Publishing House, 2003.

[2] Heng jiang-kun, Liu bin, Wang yu, the process that the Global response to climate change impacts on China, Science, 2008 (11)

[3] Bao jian-qiang, miao yang, chen feng, Low-carbon economy:the new revolution in economic development, China Industrial Economy, 2008 (4)

[4] Li hong-jun, liu wen-ge, sun xin, Carbon reduction technology, China Coal, 2008 (10).

[5] Wang Li, Liu Ying-zong. Game Analysis and Counterm Easures between the Government Supervision and the Pollution Township Enterprise[J]. Chinese Agricultural Mechanization, 2009,6.

[6] Xie Jun'an, Hao Dongheng, Xie Wen. Ideas and countermessures of Developing Low Carbon Economy[J]. Contemporary Economiy and Management, 2008,12.

[7] [7] Jin Le-qin, Liu Rui. Low Carbon Economy and Economy Development Transform in China[J]. Economics Exploration, 2009,1.

[8] Fu Yun, Ma Yong-huan, Liu Yi-jun, Niu Wen-yuan. Development Patterns of Low Carbon Economy[J]. China Population, Resources and Environment, 2008,3.

[9] Feng Jun-xin. Economic Development and Reduction of GHG Emission[J]. Journal of RenMin University of China, 2010,2.

[10] Chen Xin-ping.Tax Policy Choose in the Type of Developing Low Carbon Economy--Experience of the Developed Countries[J]. Macroeconomics and Management, 2010,4.