
Research on the Government's Roles in Enterprise Green Supply Chain Management

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Abstract: Green supply chain management (GSCM) plays a crucial role in promoting supply-side structural reform. However, enterprises are not active in action since the development and operation costs of GSCM will erode their profits. Thus, the government should provide active intervention that focuses on identifying its position, that is to say, what are the roles of the government in promoting the implementation of GSCM in enterprises. A theoretical analysis shows that the roles of the government in promoting the implementation of GSCM in enterprises can be boiled down to four types: supervisor, supporter, enforcer and coordinator. According to the result of the theoretical analysis, this paper build an evolutionary game model between the government and GSCM enterprises, to discuss what a kind of role the government should play in intervening the game situation in different contexts to encourage enterprises to implement GSCM, and prove the correctness of the theoretical analysis. At last, this paper puts forward some suggestions on how to realize these roles of the government based on the result of the model.

Keywords: Government's Roles, GSCM, Evolutionary Game, Stakeholder

1. Introduction

Green supply chain management (GSCM) involves in a theory based on environmental technology and supply chain management technology, aiming to realize environmental protection and the optimal utilization of resources. With the development of GSCM and the increase in the market share of green products, many companies have begun to release eco-friendly products in the market. On the other hand, the acceleration of climate change, depletion of natural resources and air and water pollution have improved the public awareness of environment. The environmental protection concepts of non-government organizations (NGOs) also put more pressures on enterprises. The increasing demands for eco-friendly products, as well as the pressures from NGOs and the government, encourage enterprises to gradually implement GSCM in their business modes.

At present, it is urgent to make breakthroughs in many

technological difficulties in China's GSCM. It is required to highly invest in the R&D and operation, which will erode the profits of these enterprises and discourage them to implement GSCM. According to the study of Utting, corporate self-regulation is mainly to enhance reputation and public impression, instead of the implementation of sustainability goals [1]. The mechanism of self-regulation fails. Therefore, to boost the implementation of GSCM only by resorting to corporate self-regulation and self-paying R&D is not effective. It is necessary for the government to provide intervention that focuses on identifying its role. This paper first studied the government's roles in promoting the implementation of GSCM. Then it proved the roles the government should play by using evolutionary game and provided a feasible path to study the government's roles.

2. Literature Review

Li Xiaoxi *et al.* and Wang Shaoqing *et al.* discuss the government's role in building ecological civilization [2, 3]. The authors propose that the government is the leader of construction, the advocator of concepts, the developer of systems, the executor and the major participator of cooperation. Zhao Yuan studies the role of the government in China's low carbon economy, puts forward that the government plays the following roles: the constitutor of systems, the advocator of concepts, the coordinator and supervisor of society [4]. The above articles emphasize the roles as the developer of systems and the advocator of concepts, and they are two similar Chinese literature on the government's roles in GSCM.

On the basis of the stakeholder theory, Meixell, M. *et al.* and Duan Wen *et al.* propose that the government, NGOs, media and clients should be regarded as the stakeholders of the supply chain that may affect distributors, manufacturers and suppliers, and these stakeholders will be affected by the supply chain [5, 6]. Based on the stakeholder theory, the institutional theory and the resource-based view (RBV), Hossein Nezakati establishes a model of positioning the government's roles in GSCM and puts forward the argument that the government serves as the enforcer, supporter and administrator [7].

According to these literature, it is found that there have been only a few literature on the government's roles in GSCM at present, and literature at home and abroad have not built mathematical models to analyze the correctness and roles of the government and have failed to put forward the corresponding policy suggestions on the realizations of the above roles. In this paper, supplemental studies is conducted on these problems and the correctness of the government's roles as described in the theoretical analysis is proved by the evolutionary game method, and on this basis the corresponding policy suggestions is offered.

3. The Government's Roles in GSCM

In the implementation of GSCM, enterprises need to invest a lot in R&D and operation. In addition to the pressure from corporate social responsibility, enterprises themselves have no

impetus to implement such management. Furthermore, total independence on corporate self-regulation is not feasible as the main objective of corporate self-regulation is to maintain the enterprise's reputation and public image and avoid huge economic loss. Therefore, the government or NGOs should get involved to perform joint supervision.

The government can affect the stakeholders (such as NGOs, media and consumers) of the GSCM enterprise by persuasion, admittance, rationing or other policies, thereby influencing the resources allocation within and beyond the company. The government can also promote the development of GSCM by offering subsidies to consumers or companies. Subsidizing consumers can improve the market share of the company's products, while subsidizing the company can reduce its R&D expenditure. In addition, the government may encourage media to publicize the company and improve the enterprise's reputation and public acceptance.

Second, the government can directly impose punishment on those companies that do not implement GSCM and collect environmental protection tax and pollution fees from them. Such role is called enforcer. The government may establish GSCM standards for their products. If an enterprise violates laws and rules, the government may compel the enterprise to correct its misdeed by collecting high tax and direct penalty. Also, the company can disclose the company's bad behavior via news media to destroy the company's reputation and public image.

Finally, there exists the problem of environmental protection cost apportionment and approach to cooperation among the members of green supply chain. Most of external members of green supply chain are distributed in different provinces and cities and even foreign regions. In addition to the coordination of tax, there are different industry policies in different regions. The government may play the role of coordinator who coordinates their internal and external contradictions.

In the following, the government's roles as the supervisor, supporter and enforcer will be analyzed. Since the internal and external contradictions of the GSCM enterprise are very complicated, different coordination strategies are required to solve different problems. However, there is limited space to cover these strategies. The government's role will be discussed as the coordinator in future studies.

4. An analysis of the Evolutionary Game Model

4.1. Description of Variables

Table 1. Description of the model variables.

Variable	Description
S_G	Supports from the government, such as offering subsidies or rebate taxes to the green supply chain enterprises
S_S	The government brings benefits to the enterprises by influencing their stakeholders. For example, NGOs offer more cooperation opportunities to the GSCM enterprises, and the positive publicity via media will also improve the corporate image, drive consumption and increase the market share of the enterprises.
R_g	The benefits of implementing GSCM.
C_E	The costs of implementing GSCM, including the cost of developing green technologies and the operation cost of GSCM.
pen_G	The government imposes penalty on those enterprises failing to implement GSCM. Such failure will result in resources waste and environmental pollution.

Variable	Description
pen_s	The government causes indirect loss to enterprises through stakeholders, for instance, damage to corporate reputation, entering the negative list, market share decline, etc.
C_G	The cost of government supervision. It refers to the manpower and material resources invested in enterprise supervision by the government.
T_G	The cost of government administration. It refers to that the government needs to regulate the resources waste and environmental pollution resulted from the enterprises' failure to implement GSCM.
Note:	All the variables above are non-negative numbers.

4.2. The Game Matrix Between the Government and Enterprises

Table 2. The evaluation game matrix between the government and enterprises of GSCM.

Government Enterprises	Implement and develop GSCM	Do not implement and develop GSCM
Proper supervision	$(-C_G - S_G, -C_E + S_G + S_S + R_g)$	$(-T_G - C_G + pen_G, -pen_G - pen_s)$
Lax supervision	$(-S_G, -C_E + S_G + S_S + R_g)$	$(-T_G, 0)$

Table 2 shows the game matrix between the government and GSCM enterprises. Let's take the first column as an example. When the government supervision is properly placed, the enterprise will bear the operation and R&D development cost of GSCM C_E to get the government's support S_G if it implements GSCM, and the enterprise obtains resources and gets revenue S_S under the influence of the government via the stakeholders, as well as revenue R_g due to the implementation of GSCM (for example, cost reduction). Here this paper has that the government pays the supervision cost C_G and the support cost S_G . When the government relaxes the supervision, the enterprise's total revenue remains the same as before if it fails to implement GSCM, but the government still needs to pay the support cost S_G (the supports from the

government are usually released by laws or administrative regulations. Even if the government relaxes its supervision, the enterprise is still qualified to apply the corresponding policy subsidy due to the implementation of GSCM. In China, the supervisors are often the Quality Supervision Department and the Department of Environmental Protection, while the executors of supporting policies are primarily the Department of Finance and the Revenue Department).

4.2.1. An Analysis of Enterprise Gaming

It can be assumed that x is the probability of proper supervision, $1-x$ is the probability of relaxed supervision, y is the probability that the enterprise implements GSCM, and $1-y$ is the probability that the enterprise does not implement GSCM. The utility function of enterprise is:

$$V_1 = x(-C_E + S_G + S_S + R_g) + (1-x)(-C_E + S_G + S_S + R_g) \tag{1}$$

After rearranging, get $V_1 = -C_E + S_G + R_g + S_S$. Similarly, get $V_0 = -pen_G \cdot x - pen_s \cdot x$.

According to $\bar{V} = yV_1 + (1-y)V_0$, calculate the average utility of the GSCM enterprise and get equation.

$$\bar{V} = -yC_E + yS_G + yS_S + yR_g - pen_G \cdot x - pen_s \cdot x + pen_G \cdot xy + pen_s \cdot xy \tag{2}$$

Try $F(y) = \frac{dy}{dt} = y(V_1 - \bar{V})$ and solve it to get equation (3).

$$F(y) = y(1-y)[-C_E + S_G + S_S + R_g + pen_G \cdot x + pen_s \cdot x] \tag{3}$$

(1) When $x = \frac{C_E - S_G - S_S - R_g}{pen_G + pen_s}$, V remains constant, independent of the value of y . In such situation, $\bar{V} = S_G + S_S + R_g - C_E$. If the government increases the subsidy amount or tax rebate and allows the enterprise to get more resources through the stakeholder, the average utility of the enterprise will be improved, such that the enterprise will be more willing to implement GSCM. The government's role as the supporter plays a great part in this process.

(2) Try equation (3)=0. It can be known that the constantly stable point of the equation is $y=0$ or $y=1$.

(I) At the constant point $y=0$, $\bar{V} = -x \cdot (pen_G + pen_s) < 0$. The enterprise utility function is negative at the point.

According to the analysis of the average utility function (10) of the government, the government will definitely increase the intensity of supervision while increasing the penalty, thus increasing the average utility. The government plays the roles of supervisor and enforcer.

(II) At the constant point $y=1$, the enterprise will implement GSCM. There is no need to consider whether the government will monitor the enterprise.

(3) It is important to consider the situation when $0 < y < 1$ since the enterprise's game decision-making will vary with the benefit situation. According to the stability theorem and the characteristics of evolutionary stable strategy (ESS), solve the first derivative of y in equation (3):

$$\frac{dF(y)}{dy} = (1-2y)[x \cdot pen_G + x \cdot pen_S + S_G + S_S + R_g - C_E] \quad (4)$$

An equilibrium state of evolutionary game will appear when $\frac{dF(y)}{dy} < 0$ [8, 9, 10]. Classified discussions on equation (4) as follows: There are two situations when $x \neq \frac{C_E - S_G - S_S - R_g}{pen_G + pen_S}$:

(I) If $\frac{C_E - S_G - S_S - R_g}{pen_G + pen_S} < 0$, namely $C_E < R_g + S_G + S_S$,

then $x > 0 > \frac{C_E - S_G - S_S - R_g}{pen_G + pen_S}$, and here $y=1$. Therefore, if

the government offers a very high subsidy and places the supporting policy properly, and NGOs, media or the public give more supports, that is to say, S_G and S_S in the above equation go up, then the enterprise will take the initiative to implement GSCM. The government serves as a supporter. Thus, the importance of its role as the supporter is proved.

(II) If $\frac{C_E - S_G - S_S - R_g}{pen_G + pen_S} > 0$, namely $C_E > R_g + S_G + S_S$,

then there will be three situations:

(a) If $0 < x < \frac{C_E - S_G - S_S - R_g}{pen_G + pen_S} < 1$, and $\frac{dF(y)}{dy} < 0$ is

met, then $y=0$, indicating that if there is inadequate supervision or inaction, the enterprise will give up GSCM. Thus, the importance of the government's role as the supervisor can be confirmed.

(b) When $0 < \frac{C_E - S_G - S_S - R_g}{pen_G + pen_S} < x < 1$, and if

$\frac{dF(y)}{dy} < 0$ is met, then $y=1$, suggesting that improving the

intensity of supervision will promote the enterprise to implement GSCM. As a result, it proves the importance of the government's role as the enforcer.

(c) When $\frac{C_E - S_G - S_S - R_g}{pen_G + pen_S} > 1$, then

$0 < x < \frac{C_E - S_G - S_S - R_g}{pen_G + pen_S}$ and $y=0$. Here

$C_E > pen_G + pen_S + S_G + S_S + R_g$. In other words, when the cost of implementing GSCM by the enterprise is far higher than the penalty and subsidy imposed by the government and stakeholders under the encouragement of the government, the enterprise will choose to give up GSCM. Then the government may release the policies of imposing higher subsidy and penalty, put pressure on the enterprise through NGOs, publicize the positive image of GSCM enterprises via media and increase its market share, thus greatly improving the enterprise's revenue due to the implementation of GSCM and help the enterprise to transform from situation (c) to (a). It can be seen that the government's roles as the enforcer and supporter are very important and effective.

Considering each of these conditions, enterprises will give a certain response to the government's decision-making. However, the government can play different roles to improve the result of game and encourage them to implement GSCM. In the above-mentioned model analysis, it has been proven the correctness and importance of the three roles of the government: supervisor, supporter and enforcer. Some policy suggestions have also been given in brief based on the result of the model. The government can play different roles and use the corresponding policy tools to encourage enterprises to develop GSCM. But how to help the government play these roles? This paper will continue to explore the game of the government, thus putting forward some suggestions for the government to realize its roles.

4.2.2. An Analysis of Government Gaming

The utility function of proper supervision by the government is described as:

$$U_1 = y(-C_G - S_G) + (1-y)(-T_G - C_G + pen_G) \quad (5)$$

After rearranging:

$$U_1 = -yS_G - T_G - C_G + pen_G + yT_G - ypen_G \quad (6)$$

Similarly, the utility function of improper supervision by the government is described as:

$$U_0 = yT_G - T_G - yS_G \quad (7)$$

Calculate the average utility of the government according to $\bar{U} = xU_1 + (1-x)U_0$, the result is:

$$\bar{U} = -xC_G + x \cdot pen_G - xy pen_G + yT_G - T_G - yS_G \quad (8)$$

Try $F(x) = \frac{dx}{dt} = x(U_1 - \bar{U})$. Substitute in equation (5) and (8) to get:

$$F(x) = x(1-x)[pen_G - ypen_G - C_G] \quad (9)$$

(1) When $y = \frac{pen_G - C_G}{pen_G}$, evolutionary game will be kept at the constantly stable state all the time. According to equation (8) when $\bar{U} = y(T_G - S_G) - T_G < 0$, the average utility of the government is negative. Here the government will reduce its subsidy as much as possible. According to the analysis when $y = \frac{pen_G - C_G}{pen_G}$, if the government wants to encourage the enterprise to implement GSCM, it can simply increase the penalty amount, thus improving the probability of implementing GSCM by the enterprise and encouraging the enterprise to improve its behaviors. According to the analysis of enterprise gaming in 4.2.1, the enterprise will take the initiative to implement GSCM.

(2) By assuming equation (11)=0, definitely that the stable point will appear on $x=0$ or $x=1$:

(I) When $x=0$, according to equation (2), the enterprise

will determine whether to implement GSCM based on offset balance between the R&D expenditure and revenues of green supply chain and the government's subsidy. Here if the government elevates subsidy and increase resources available to the enterprise by influencing NGOs, media and the public, then the enterprise will undoubtedly implement GSCM.

(II) When $x=1$, according to equation (2), $\bar{V} = -(1-y)(pen_G + pen_S) + y(S_G + S_S + R_g - C_E)$. In order to improve the enterprise's average utility, it will vigorously implement GSCM. According to the equation above, if the government wants to increase the subsidy and influence more stakeholders to make more resources available to the enterprise, then the enterprise utility will increase greatly. In other words, when the government's supervision intensity is extremely high, the subsidy provided to the enterprise is relatively high, and there is policy support, then the enterprise will finally implement GSCM. Thus, it can be proven that the government's roles as the supervisor and supporter are critically important.

(3) In practice, enterprises and the government will constantly adjust their own gaming stratifies according to the actual condition. As a result, attach much importance to the gaming between GSCM enterprises and the government is necessary when $0 < x < 1$. Similarly, when $y \neq \frac{pen_G - C_G}{pen_G}$

and $\frac{dF(x)}{dx} < 0$ is met, evolutionary game will reach a stable state. There are several conditions as follows:

(I) When $\frac{pen_G - C_G}{pen_G} < 0$, namely $pen_G < C_G$, then $y > \frac{pen_G - C_G}{pen_G}$ as y meets the condition of $0 \leq y \leq 1$.

According to $\frac{dF(x)}{dx} = (1-2x)[pen_G - ypen_G - C_G]$, the condition of $\frac{dF(x)}{dx} < 0$ will be met only when the stable

result of evolutionary game is $x=0$. Here the best strategy of the government is to maintain the state of relaxed supervision. From the perspective of the government's balance of payments, here the penalty is smaller than the supervision cost of the government that remains high. Thus, to increase penalty or reduce the supervision cost is relatively important to promote the government to play the role of the supervisor.

(II) Assume that $\frac{pen_G - C_G}{pen_G} > 0$, namely $pen_G > C_G$.

Apparently, $0 < \frac{pen_G - C_G}{pen_G} < 1$. Here need's to analyze the probability distribution of y . There are two situations as below:

(a) By assuming that $y > \frac{pen_G - C_G}{pen_G}$, here $0 < \frac{pen_G - C_G}{pen_G} < y < 1$, namely $pen_G - ypen_G - C_G < 0$.

According to $\frac{dF(x)}{dx} < 0$, the stable result of evolutionary game is $x=0$. That is to say, if the possibility that the enterprise implements GSCM is high, the government may give no supervision.

(b) Assume $y < \frac{pen_G - C_G}{pen_G}$, and hence $0 < y < \frac{pen_G - C_G}{pen_G} < 1$, namely $pen_G - ypen_G - C_G > 0$. in

order to meet $\frac{dF(x)}{dx} < 0$, then the stable result of evolutionary game is $x=1$. This suggests that it the possibility that the enterprise implements GSMC is small, the government will increase its intensity of management.

To sum up, when the government's penalty is harsh or the supervision cost is low, and the enterprise is less willing to implement GSCM, the government will actively play the role of supervisor. However, when the government's penalty is low or the supervision cost is high, and the enterprise is willing to implement GSCM, the government tends to relax its supervision. Therefore, in order to encourage the government to play its roles, the government needs to make ends meet, lower the supervision difficulty and cost, and introduce public scrutiny to monitor the "government supervisor". Otherwise, the government will probably relax its supervision or fail to do its job.

4.2.3. Illustrations for Evolutionary Game

Figure 1 shows the results of the game between the government and enterprises. It can be seen from the four quadrants of the figure that there is no stable point of evolutionary game between the government and enterprises.

- (1) When X and Y are in quadrant I, the equilibrium point of game is (1,0);
- (2) When X and Y are in quadrant II, the equilibrium point of game is (1,1);
- (3) When X and Y are in quadrant III, the equilibrium point of game is (0,1);
- (4) When X and Y are in quadrant IV, the equilibrium point of game is (0,0);

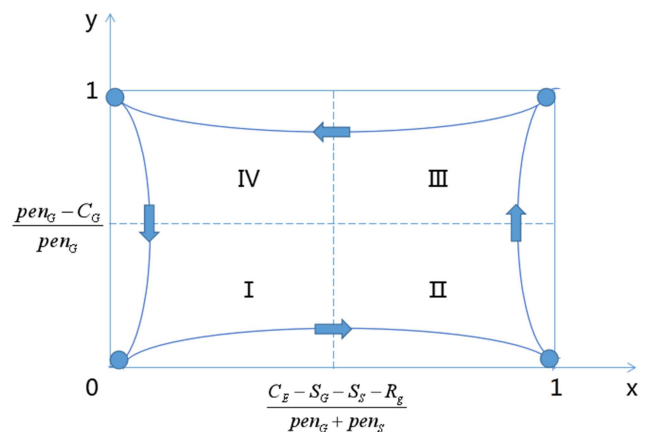


Figure 1. The preliminary result of game.

If the government plays the corresponding role to intervene the game situation above, the overall game result will change. The goal is to encourage the enterprise to finally implement GSCM. Meanwhile, the enterprise will give up GSCM if the government adopts the strategy of deregulation. Therefore, the government need effectively play its role as the supervisor. The result of intervention is shown in Figure 2.

(1) When the government increases the penalty on or collects a high environmental pollution tax from those enterprises failing to implement GSCM as the enforcer, $\frac{pen_G - C_G}{pen_G}$ will change to $\frac{pen_G - C_G'}$ and shift from position a to position b on the vertical axis; when the government offers subsidies to GSCM enterprises, increases their revenues through their stakeholders and strengthens the punishment, then $\frac{C_E - S_G - S_S - R_g}{pen_G + pen_S}$ will change to $\frac{C_E - S_G - S_S - R_g'}$ and shift from position a to position b on

the transverse axis. The execution of the above-mentioned roles will result in the gradual expansion of Zone III, and the result of the game between the government and enterprises will largely fall within Zone III in which enterprises implement GSCM.

(2) When the result of the game between the government and enterprises falls within Zone IV, to strengthen the public's supervision of the government, reduce the supervision cost of the government and improve the internal assessment system of the government can help its gaming strategy move from Zone IV to Zone III and prevent enterprises from giving up GSCM after the government relaxes its supervision.

(3) When the result of the game between the government and enterprises falls within Zone II, the government will play the role of supervisor, which will help enterprises move from Zone II to Zone III.

To sum up, the government's roles are extremely important in encouraging enterprises to perform GSCM, and the government forces the equilibrium point of the overall game to move towards point A by playing various roles.

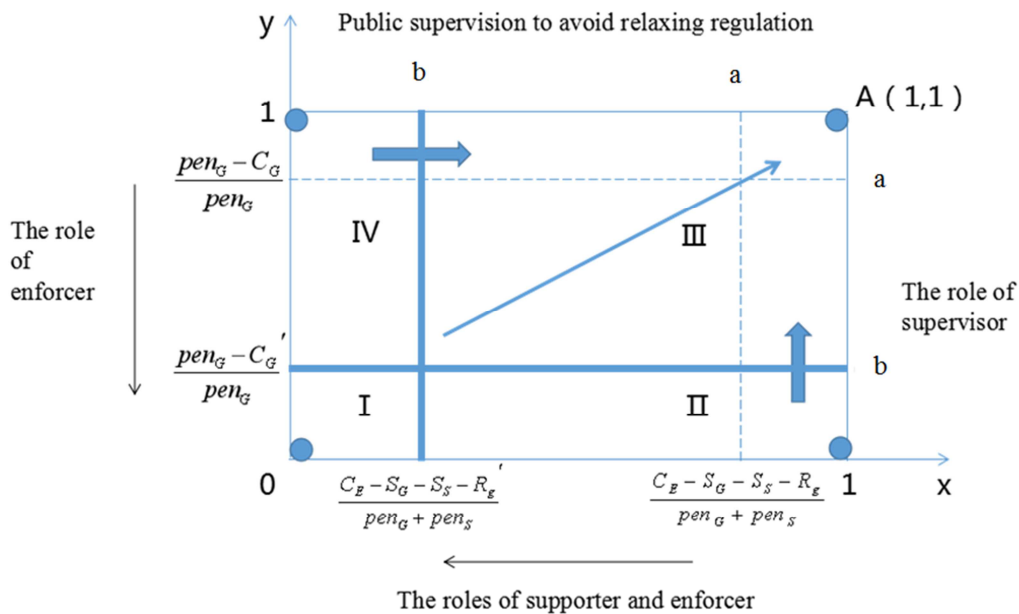


Figure 2. The game result after the intervention of the government's roles.

5. Conclusion and Suggestions

5.1. The Main Conclusion

The government can directly influence GSCM enterprises by giving subsidy, imposing punishment or developing green standards, or indirectly influence the stakeholders of GSCM enterprises (NGOs, media and consumers) to improve their operation. This paper proposes the four important roles of the government in influencing the implementation of GSCM: coordinator, supporter, supervisor and enforcer. The latter three are analyzed by the methods of evolutionary game on account of space limitation, and in this paper it is focused on how the government changes the game situation and

encourage enterprises to implement GSCM by playing different roles. On this basis, this paper further explore the government's responses to different behaviors of enterprises and thereby put forward appropriate suggestions on how to better play the government's roles.

5.2. Suggestions on How the Government Plays Its Roles

5.2.1. Strengthen Public Supervision and Urge the Government to Play the Corresponding Role

As described in 4.2.2 in this paper, if an enterprise is highly willing to implement GSCM, the government will curtail its supervision, relax and even fail to do its job. When the government reduces its supervision, enterprises will follow the strategy of not implementing GSCM. As a consequence,

the government and enterprises enter a recurrent evolutionary game. The government is the agent of public rights, and the public has the right to supervise the government. Thus, strengthen public supervision of the government and encourage the government to play its roles and perform the corresponding functions is important.

5.2.2. Properly Use the Forces of NGOs and Media to Reduce the Supervision Cost

As depicted in 4.2.2, when the government's supervision cost and difficulty remain high, the government will reduce the cost incurred by playing the corresponding roles from the perspective of balance of payments. Thus, the government may give some reasonable authorizations to NGOs and introduce the forces of media and society to jointly supervise enterprises and reduce the supervision cost.

5.2.3. Establish Sound and Efficient Laws and Regulations and Improve the Policy Tools That Support the Government's Roles

The realization of the government's role depends on policy tools. For example, the role of supporter requires the supports of financial subsidy and tax subsidy policies; the role of enforcer requires the supports of administrative penalty, collection of environmental pollution tax, etc. The realization of all these roles should be assisted by establishing sound and efficient laws and regulations.

5.2.4. Improve the Internal Structure of the Government and Social Governance, Act with United Strength and Promote Development

The model analysis in this paper reveals that the implementation of GSCM within enterprises requires the participation of the government, and the realization of the government's roles should be done with the collaborations among different departments and even the whole society because a single department cannot solve the problem. It is necessary to improve the collaboration mechanism of the organizations within the government and the structure of social governance, and to promote the government, society

and enterprises to establish a good relationship of cooperation and mutual assistance in order to boost the implementation of GSCM.

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