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Analysis of enterprise and government game based on the environmental management level

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ABSTRACT

Due to the development of the environmental industry enterprise of our country management level are not balanced, the lack of effective promotion measures. In this paper, it is assuming the enterprise environmental technology business success and failure and whether the government raise environmental standards, the final result of evolution of government and enterprises to choose their strategies in different conditions. Enterprises and government in the policy choice is negatively related to. Government failure on the technological upgrading of enterprises will continue to have a significant impact on transformation. The government revises the environmental standards to promote enterprise environment management level. On the evaluation of the level of corporate environmental management supervision cost, banned between corporate cost size have a significant impact on the government behavior strategies.

KEYWORDS

Environmental management enterprise; The government; Evolutionary game theory.

INTRODUCTION

In the spring of 2014, the Beijing Tianjin Hebei region suffered serious haze, National Meteorological Center issued from the fog warning, starts emergency plans governments haze. Haze severely affected people's life and social economic development. According to the analysis of Shanghai during 2012 -2013, 2013 -2014 air sampling data, industry of Shanghai is the main source of air pollution. Industrial production process emissions, industrial boilers and furnaces, power plant emissions account for emissions of air pollutants 32.9%. The industrial production is the source of many environmental problems. Therefore, many industrial enterprises of China also began to explore the harmony between economic development and environmental protection way. Many heavy pollution enterprises introducing the concept of environmental management, but the management level of management of industrial enterprises and environment in China is inefficient. There is a strong guiding role of environmental management behavior of the government industry policies on enterprise. To improve environmental management level at this stage mainly rely on government environmental policy orientation, encourage industrial enterprises to reduce pollutant emissions by improve technology. In this paper, it uses game analysis of relationship between government and enterprise. Then the enterprise and government behavior under different conditions were obtained conclusion the evolution of evolution. To provide reference for government policy guidance and effective environmental management of enterprise strategy choice of enterprises.

At this stage to promote the enterprise environment management level and management level of research. Luo Wenbing, Liu Aidong, Deng Mingjun propose the environmental management level evaluation system to make the enterprise active implementation of environmental responsibility and environmental strategy of enterprise. Then they put forward a framework of research. Through the investigation into the enterprises in Changzhutan, found the enterprise environment serious impact on the economy. There are scholars study on enterprise environmental pollution related problems[1]. In the study of corporate environmental behavior and government regulation, Kong Pengz Hi Yang Zhongzhi find that only the government sold part of economic interests through tax policy constraints of traditional backward industries. It can improve public participation in order to achieve the optimal cycle of waste in combination of policy actions[2]. Wang Xiuli, Li Jian, Wei Xiaoping, Li Kun using replicated dynamic evolutionary game analysis of the chain ecological industry obtain that environmental constraints and subsidies to enterprises is beneficial to enterprises towards the ecological evolution of the enterprise. Through the principal-agent model design of enterprise and government to implement green management research[3-4].

GAME ANALYSIS OF THE GOVERNMENT AND ENTERPRISES

Hypothesis: The government and enterprises are bounded rationality, in order to realize own benefit maximization. They are all in order to maximize their own benefits. The enterprise to maintain the original environment management levels of utility is U_1. Due to the technological transformation of enterprises need one-time input technology costs E. Environmental management to enhance the level of technology is the industry leading technology. Transformation process has certain success probability of e. Technical improvement of enterprises to reduce pollution treatment cost is C_1, and the technology after the success of the transformation must break through the original environmental management level[5]. In the environmental management level, increase the enterprise terminal market efficiency is ΔU_1. The government does not encourage enterprises to improve environmental management level of utility for U_2. The government to the enterprise environment management level to re evaluate need the cost C_2. Enterprise environment management level can improve the emissions per unit output in the region, and to allow more enterprises to enter, In addition because the improvement of the environment to get other social income and government revenue ΔU_2[6]. Government to achieve high environmental management level of enterprises incentives is for S. Because of the development of social economy, pollution levels improving and the public improvement of environmental quality, the government will set new emission standards or environmental control measures. The probability of an event for is r. After the occurrence of, enterprises face huge policy punishment cost is C_3[7], the government environmental governance gains relative. According to the hypothesis of these conditions, establish the game matrix as shown in TABLE 1.

TABLE 1 : The game matrix of government and enterprises

Government Enterprises	Promote environmental management	Don't promote environmental management
Improve enterprise environment management level	$U_1+C_1-Ee+\Delta U_1+S$, $U_2-C_2+\Delta U_2-S$	$U_1+C_1-Ee+\Delta U_1$, $U_2+\Delta U_2$
Maintain the original level of environmental management	U_1-C_3r, $U_2-C_2+C_3r$	U_1, U_2

In reality, because the technology investment returns relative lag, the technological upgrading of enterprises cost is greater than the benefit, enterprise investment in early $U_1+C_1-E<0$. In order to ensure the implementation of environmental management level dynamics, the cost of corporate environmental rectification process must make the enterprises' utility is negative $U_1-C_3r<0$.

Because there is no pure strategy Nash equilibrium in mixed strategies. Assumptions: Improving environmental management level of enterprises, the probability is *p*, to maintain the original level of probability of environmental management is for *1-p*, the government to the enterprise incentive to *q*, do not encourage *1-q*.

Calculation of enterprises to improve environmental management level of expected return W_1 and maintain the original environment management level is W_2, and the average yield of enterprise is $\overline{W}$.

$$W_1 = q(U_1 + C_1 - Ee + \Delta U_1 + S) + (1-q)(U_1 + C_1 - Ee + \Delta U_1),$$

$$W_2 = q(U_1 - C_3 r) + (1-q)U_1, \quad \overline{W} = pW_1 + (1-p)W_2$$

Similarly, the calculation of government enterprise environment management level to take the expected return M1 incentives, expected return M2 is not encouraging, and the government average yield of $\overline{M}$.

$$M_1 = p(U_2 - C_2 + \Delta U_2 - S) + (1-p)(U_2 - C_2 + C_3 r),$$

$$M_2 = p(U_2 + \Delta U_2) + (1-p)U_2, \quad \overline{M} = qM_1 + (1-q)M_2$$

Because of the government and enterprises are rational, the game after long time comparison of different strategies under the income level, can be obtained in low income strategy game people will change their strategy, strategy development to the high profits. Therefore, the model of p and q changes over time quantity. A strategy of dynamic evolution equation of probability change rate is equal to the relative fitness, if take the strategy of fitness than the average fitness is high, the time evolution of the probability will increase. The replicated dynamic equation of government and enterprise strategy[8]:

$$d_p / d_t = p(W_1 - \overline{W}) = p(1-p)(W_1 - W_2) = p(1-p)(C_1 - Ee + \Delta U_1 + q(S + C_3 r))$$

$$d_q / d_t = q(M_1 - \overline{M}) = q(1-q)(M_1 - M_2) = q(1-q)(C_3 r - C_2 - p(S + C_3 r))$$

From the above formula for improving environmental management level of enterprises, when $q=(Ee-C_1-\Delta U_1)/(S+C_3r)$ and $Ee-C_1-\Delta U_1>0$, then $d_p/d_t=0$, and p is fixed, all the enterprises evolution strategy is fixed. In addition, when the $q\neq(Ee-C_1-\Delta U_1)/(S+C_3r)$, $d_p/d_t=0$, $p=1$ and $p=0$ is the steady state equations. And when $q<(Ee-C_1-\Delta U_1)/(S+C_3r)$, $d_p/d_t<0$, p with the evolution of time become increasingly small, evolution strategy for the final $p=0$ stable. When $q>(Ee-C_1-\Delta U_1)/(S+C_3r)$, $d_p/d_t>0$, P with the evolution of time become increasingly large, the final $p=1$ is evolutionary stable. If $Ee<C_1+\Delta U_1$, when $q\in[0,1]$, $C_1+\Delta U_1-Ee+q(S+C_3r)>0$, $d_p/d_t>0$, then $p=1$ is evolutionary stable strategy. From the show, when the enterprise environmental management level, technical input is greater than the output, if the government implementation of environmental management strategy is small, and the enterprise most for its own benefit, enterprise strategy evolution results will tend not to carry out environmental management level. If the government implementation of environmental management strategy, and through the behavior of government subsidies for enterprise technology investment, enterprise strategy evolution results will tend to promote corporate environmental management level. In the enterprise environment management techniques into less than output, regardless of whether the government implementation of environmental management strategy, enterprises will enhance the environmental management level. Due to the limitation of environmental management standards by the social economic development, the level of industrial technology and government's own intention and so on, the introduction of new standards with uncertainty. Because the enterprise environmental management reformation is not input can be successful, if the technical transformation of failure, technology costs will become silent cost, then $d_p/d_t=p(1-p)(-Ee+q(S+C_3r))$, when $q=Ee/(S+C_3r)$, then $d_p/d_t=0$, the value of p invariant, all enterprises evolution strategy is fixed. In addition, when $q\neq Ee/(S+C_3r)$, then $d_p/d_t=0$, $p=1$ and $p=0$ are steady state equation of value. when $q<Ee/(S+C_3r)$, $d_p/d_t<0$, p with the evolution of time become increasingly small, the final $p=0$ stable evolutionary strategy. When $q>Ee/(S+C_3r)$, $d_p/d_t>0$, the p along with the evolution of time become increasingly large, the final $p=1$ is evolutionary stable.

For the implementation of environmental management of the government, when $p=(C_3r-C_2)/(S+C_3r)$, and $C_3r>C_2$, then $d_q/d_t=0$, then for any q values are the same, the evolution strategy of government is stable. When $p\neq(C_3r-C_2)/(S+C_3r)$, then $d_q/d_t=0$, $q=1$ and $q=0$ are steady state equation of value. When $p>(C_3r-C_2)/(S+C_3r)$, then $d_q/d_t<0$, q with the time evolution of the value of smaller and eventually become 0. When $p<(C_3r-C_2)/(S+C_3r)$, $d_q/d_t>0$, q evolve over time value

becomes larger and eventually become 1. When $C_3r<C_2$, $d_q/d_t<0$, $q=0$ is the government along with the time evolution of the steady state.

ANALYSIS OF DYNAMIC EVOLUTION OF ENTERPRISE AND GOVERNMENT POLICY

Order, $q_0=(Ee-C_1-\Delta U_1)/(S+C_3r)$, $Ee-C_1-\Delta U_1>0$, $p_0=(C_3r-C_2)/(S+C_3r)$, $C_3r>C_2$, Establish enterprise and government strategy evolution matrix. TABLE 2, 3 said that when the enterprise policy changes cost penalty greater than the government to the enterprise environment cost management evaluation, evolution results of enterprise technology investment and income changes. TABLE 3, 4 said when the enterprise policy changes the punishment cost is less than the government to the enterprise environment cost management assessment, the evolution results of enterprise technology investment and benefits change.

TABLE 2 : Technology investment is greater than income

	$q<q_0$	$q>q_0$
$p>p_0$	P→0, q→0	P→1, q→0
$p<p_0$	P→0, q→1	P→1, q→1

When $Ee\geq C_1+\Delta U_1$, $C_3r\geq C_2$. From TABLE 2, can know the government and enterprises no evolutionary stable strategy in the strategy choice. Enterprise strategy and government policy is influence each other. When the enterprise strategy will is improved, government policy will is reduced. The government and the enterprise strategy choice has been dynamic changes.

TABLE 3 : Technology investment is less than income

	$q\in[0,1]$	
$p>p_0$	P→1, q→0	P→1, q→0
$p<p_0$	P→1, q→1	P→1, q→1

When $Ee<C_1+\Delta U_1$, $C_3r\geq C_2$. From TABLE 3, when the enterprise obtains in the promotion of environmental management level is greater than that of its investment benefit, enterprise strategy to select the final will be the environmental management level. Because the enterprise consciousness of environmental management level, the final stable state is $p=1$. Then the government will not advance the environmental management, the final stable state for $q=0$. This state is expected, but due to technical transformation income lag. In the transformation period, $U_1+C_1-Ee<0$, the enterprise timely understanding of technical transformation income is greater than investment. Because the technology investment will bring short-term heavy burden to the enterprise, and investment income may be a long process. If the initial business to improve environmental management level is lower, the government will be relatively active implementation of environmental management policy to promote the enterprises in the environmental management level. The higher the intent to ascend in the enterprise, the government environmental management policies will reduce.

TABLE 4 : Technology investment is greater than income

	$q<q_0$	$q>q_0$
$p\in[0,1]$	P→0, q→0	P→1, q→0
	P→0, q→0	P→1, q→0

When $Ee>C_1+\Delta U_1$, $C_3r<C_2$. From TABLE 4, When the enterprise evaluation cost is greater than the enterprise be cleared or mandatory upgrade cost, the government will not implement environmental management. The government for some small environmental pollution enterprises is often forced to take off, rather than support the environmental transformation. If the technical transformation of the environment cost is less than the income, the interests of enterprises will promote the enterprise environment management level. Through the TABLE 4, the government and enterprise final game stable state: Government does not implement environmental management, the enterprise will not upgrade environmental management level.

When $Ee<C_1+\Delta U_1$, $C_3r<C_2$, From TABLE 5, when the technological transformation of enterprises income is greater than the cost of renovation, and evaluation of the government cost is greater than the enterprise be cleared or mandatory upgrade cost, the final strategy steady state of government and enterprises is that the government chose not to implement environmental management strategy, the enterprises improve management level of environment. In reality, some large enterprises can withstand short-term technical investment fund pressure to upgrade the enterprise environment

management level, and to obtain better returns, such as the enterprises to implement energy-saving projects, waste recycling project to obtain benefits for the enterprise.

TABLE 5 : Technology investment is less than income

	$q \in [0,1]$	
$p \in [0,1]$	P→1, q→0 P→1, q→0	P→1, q→0 P→1, q→0

When the technical inputs as sunk costs, make $q_0=Ee/(S+C_3r)$, $p0=(C_3r-C_2)/(S+C_3r)$, $C_3r>C_2$. Establish enterprise and government strategy evolution matrix in TABLE 6, 7.

TABLE 6 : Punishment cost is greater than the cost assessment of policy

	$q < q_0$	$q > q_0$
$p > p_0$	P→0, q→0	P→1, q→0
$p < p_0$	P→0, q→1	P→1, q→1

When $C_3r>C_2$, from TABLE 6 shows: evolution strategy of enterprise and government can't form stable state. Enterprise strategy and government policy are interdependent and influence. When the failure of corporate environmental transformation, but the government to encourage environmental transformation of enterprises can compensate the environmental input, and upgrade in the environmental standard pressure enterprises will once again environmental management level. But when the enterprise location choice is to upgrade environmental management, the environmental management strategy choice of government will tend to decrease. Therefore, enterprises and government strategy choices are constrained.

TABLE 7 : Punishment cost is greater than the cost assessment of policy

	$q < q_0$	$q > q_0$
$p \in [0,1]$	P→0, q→0 P→0, q→0	P→1, q→0 P→1, q→0

When $C_3r<C_2$, From TABLE 7 shows: the government stable strategy choice is not the implementation of environmental management. At this time, in the technological transformation of enterprises after the failure, it will cause very big effect to the enterprise. The enterprise will tend to chose not to enhance environmental management level, and the strategy of stable state is not to carry out environmental management level.

When the government will not revise the new environmental standards, make $q_0=(Ee-C_1-\Delta U_1)/S$, $Ee-C_1-\Delta U_1>0$, so $d_q/d_t=q(1-q)(-C_2-pS)$, then $p \in [0,1]$, in evolution, q tends to 0. Establish enterprise and government strategy selection evolution matrix of TABLE 8, 9.

TABLE 8 : Technology investment is greater than income

	$q < q_0$	$q > q_0$
$p \in [0,1]$	P→0, q→0 P→0, q→0	P→1, q→0 P→1, q→0

When $Ee>C_1+\Delta U_1$, From TABLE 8 shows : there is a final stable evolutionary strategy of the government and enterprises.

TABLE 9 : Technology investment is less than income

	$q \in [0,1]$	
$p \in [0,1]$	P→1, q→0 P→1, q→0	P→1, q→0 P→1, q→0

When $Ee<C_1+\Delta U_1$, from TABLE 9 shows: even if the government does not carry out environmental management, the enterprise will also carry out technical transformation environment.

TABLE 10 : Government is not new standard and the technological transformation of enterprises fail

	$q<q_0$	$q>q_0$
$p\in[0,1]$	P→0, q→0	P→1, q→0
	P→0, q→0	P→1, q→0

When the government is not to amend the new environmental standards, and the enterprise technical innovation environment is failure. Make $q_0=Ee/(S+C_3r)$, then $d_q/d_t=q(1-q)(-C_2-pS)$. So $p\in[0,1]$, $q=0$. From TABLE 10 shows: The final steady state government and enterprise strategy is that the government does not chose to implement environmental management, enterprises no longer choose to upgrade the level of environmental management.

CONCLUSION

In the analysis from the above: first, technological transformation of enterprises in the environment that the benefits outweigh the transformation of enterprises environmental technology investment, enterprise will tend to carry out technical transformation without the need for the government to encourage. When enterprises try for technological transformation of environmental management failure, the decisive factor of whether the enterprise again environmental business transformation is that whether the government is compensation for enterprises. If there is no compensation, enterprises will no longer attempt to carry out technical transformation environment. Secondly, when technology investment is greater than income, the key factor is that the government encourages enterprises for the promotion of environmental management. But if the government's investment is too large, it will reduce the enthusiasm of government encouragement, so they are not stable evolution strategy. If the government does not compensate the enterprise, enterprises will not choose to carry out environmental management level. Once again, the new environmental standards have a significant impact on the environment management level. To enhance the level of environmental management strategy of enterprises to select a large part of that: If the environmental standards of the promotion, the enterprise will have huge punishment. If the enterprise determine the government will not introduce new environmental standards, in this case, enterprises in environmental management to enhance return is negative, and enterprises will not reformed and the government will not implement environmental management.

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