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Original Paper

Research on Green Construction Supervision Mechanism Based on Evolutionary Game

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Abstract

On the basis of the analysis of the game relationship between the construction enterprise and the supervision department, the evolutionary game model of the green construction supervision is established. By analyzing the unilateral stability of the game player, it is found that when the regulatory probability of regulatory authorities is maintained at the corresponding regulatory probability of the mixed strategy equilibrium point, the green construction probability of construction enterprises will evolve to 100%, and has good stability. According to this, the supervision mechanism of setting the threshold of supervision probability is put forward so as to realize full coverage of green construction.

Keywords

green construction, regulatory strategy, evolutionary game, stability analysis

1. Introduction

With the increasingly prominent resources and environmental problems, green construction has been paid more and more attention by all sides of the society. As a spokesman of the public, how to make scientific and reasonable regulatory strategies and promote green construction is a topic worthy of research and discussion.

Evolutionary game is formally proposed by Maynard Smith and Price (1973) in the study of the conflict in the biosphere, and are then widely used in the fields of economics and sociology. At present, some researchers combine evolutionary game with system dynamics to study the problems of safety production, environmental pollution, intellectual property protection and so on. For example, Cheng Min and other set up evolutionary game simulation model through system dynamics, and discussed the strategy of building safety supervision. It is considered that increasing the reward and punishment to the supervision department can improve the construction safety production status. Cai Lingru and other

studied the game problem of environmental pollution. It was found that there was no evolutionary equilibrium in the system under asymmetric mixed strategy, and then a dynamic penalty strategy was proposed to make the game system have an evolutionary stable strategy. Zhu Qinghua and other studied the related issues of carbon emissions reduction between local governments and manufacturing enterprises. Based on the dynamic punishment strategy, the dynamic reward strategy was put forward, and some boundary conditions of the game system were changed to improve the probability of carbon emission reduction measures.

The above research has solved the stability problem of the game equilibrium point, and has improved the probability of the executive's execution to a certain extent, but it needs to change some boundary conditions of the game, which is usually difficult to achieve in practice. Based on the perspective of unilateral stability analysis of the game player, this study realizes the green execution of 100% in construction enterprise without changing the game conditions.

2. The Construction of Evolutionary Game Model

2.1Model Description

Construction enterprises choose green construction with probability x, then choose non green construction with probability 1-x. The construction enterprises carry out green construction, take various measures to protect the environment and save energy, so the incremental cost will be C_1. Good green construction of construction enterprises will be included in the integrity assessment system, and it will be linked to the awards evaluation. It will accumulate advantages for future undertaking projects, and the potential future yield is R_1. Construction enterprises do not carry out green construction. They are punished by P_1 after being punished by the regulatory authorities, which includes direct economic penalties, downtime losses and future losses caused by bad credit records.

The supervisory department chooses the supervision by the probability y, then chooses the non-supervision by the probability 1-y. The cost of supervising the construction enterprises for green construction is C_2. If the supervision department does not act on the construction enterprise's non green construction, it will be subject to the loss of duty by the superior department in charge of P_2. Non green construction of construction enterprises has a negative impact on the environment. For example, the social welfare loss caused by vehicle washing facilities and pollution of urban roads at the construction site is G_2.

Based on the above hypothesis and description, the evolutionary game payment matrix of the construction enterprise and the regulatory department is shown in Table 1.

Table 1. Game Payment Matrix of Construction Enterprise and Supervision Department

		Regulatory Department	
		Supervision	Non supervision
Construction Enterprise	Green construction	$-C_1+R_1$ ， $-C_2$	$-C_1$ ， 0
	Non green construction	$-P_1$ ， $-C_2-G_2$	0 ， $-G_2-P_2$

2.2 The Construction of Evolutionary Game Model

Based on the local people's payment matrix under the combination of various strategies above, the dynamic evolution equation of the evolutionary game of the building enterprise and the regulatory department is constructed.

The expected earnings of green construction E_{1Y}, the expected earnings of non green construction E_{1N} and the average expected return $\overline{E}_1$ of the construction enterprise are respectively (1)–(3)

$$E_{1Y} = y(-C_1 + R_1) + (1-y)(-C_1) = yR_1 - C_1 \tag{1}$$

$$E_{1N} = y(-P_1) = -yP_1 \tag{2}$$

$$\overline{E}_1 = xE_{1Y} + (1-x)E_{1N} = xy(R_1 + P_1) - xC_1 - yP_1 \tag{3}$$

According to the formula (1)-(3), the replication dynamic equation of the construction enterprise is shown.

$$F(x) = \frac{dx}{dt} = x(E_{1Y} - \overline{E}_1) = x(1-x)(yR_1 - C_1 + yP_1) \tag{4}$$

The expected earnings of supervision E_{2Y}, the expected earnings of non-supervision E_{2N} and the average expected return $\overline{E}_2$ of the regulatory department are respectively (5)-(7).

$$E_{2Y} = x(-C_2) + (1-x)(-C_2 - G_2) = -C_2 - G_2 + xG_2 \tag{5}$$

$$E_{2N} = (1-x)(-G_2 - P_2) = -G_2 - P_2 + xG_2 + xP_2 \tag{6}$$

$$\overline{E}_2 = yE_{2Y} + (1-y)E_{2N} = -xyP_2 + x(G_2 + P_2) + y(P_2 - C_2) - G_2 - P_2 \tag{7}$$

According to the formula (5)-(7), the duplication dynamic equation (8) of the regulatory department is shown.

$$F(y) = \frac{dy}{dt} = y(E_{2Y} - \overline{E}_2) = y(1-y)(P_2 - C_2 - xP_2) \tag{8}$$

Combined formula (4) and formula (8), the dynamic equations of the evolutionary game replication between the construction enterprises and the regulatory departments are set up.

$$\begin{cases} F(x) = \dfrac{dx}{dt} = x(E_{1Y} - \overline{E}_1) = x(1-x)(yR_1 - C_1 + yP_1) \\ F(y) = \dfrac{dy}{dt} = y(E_{2Y} - \overline{E}_2) = y(1-y)(P_2 - C_2 - xP_2) \end{cases} \tag{9}$$

3. Optimization of Green Construction Supervision Mechanism

3.1 Analysis of the Unilateral Sability of Game Player

According to the change of each other's strategy, the game player constantly learn and adjust their own strategies so as to achieve the goal of maximizing the income. Based on the principle of maximizing revenue, after a period of game, when the probability of green construction of construction enterprises reaches a higher level, the regulatory authorities will reduce the probability of supervision. Construction enterprises learn to reduce the probability of supervision, adjust their own strategies to reduce the probability of green construction, and the game between the two sides is so reciprocated. But in the real green construction supervision in construction enterprises, even if the green construction probability reaches 100%, the probability of 0% can make the supervision supervision department of revenue maximization, but regulators will not take the supervision probability of 0% strategies, but to maintain a minimum, basic regulatory probability. Based on the above facts, this section, from the perspective of unilateral stability analysis, explores the internal mechanism and setting method of setting the threshold of supervision probability.

By formula (4), it is known that the replicating dynamic equation of the building enterprise is,

$$F(x) = \frac{dx}{dt} = x(1-x)(E_{1Y} - E_{1N}) = x(1-x)(yR_1 - C_1 + yP_1)$$

When $Y = \dfrac{C_1}{R_1 + P_1}$, $F(x) \equiv 0$, for any x is a stable state, also means that the construction enterprise green construction probability x for any value can remain stable.

When $Y \neq \dfrac{C_1}{R_1 + P_1}$, order $F(x)=0$, x = 0, x = 1 is the two equilibrium point of X. For the derivation of X, the formula (10) is obtained.

$$\frac{dF(x)}{dx} = (1-2x)(yR_1 - C_1 + yP_1) \tag{10}$$

According to the stability properties of differential equations, when $\left.\dfrac{dF(x)}{dx}\right|_{x=x^*} < 0$, x = x* is an evolutionary stable equilibrium point, and the corresponding strategy is the evolutionary stable strategy.

When $Y < \dfrac{C_1}{R_1 + P_1}$, $\left.\dfrac{dF(x)}{dx}\right|_{x=0} < 0$, $\left.\dfrac{dF(x)}{dx}\right|_{x=1} > 0$, so x = 0 is an evolutionary stable equilibrium point;

When $Y > \dfrac{C_1}{R_1 + P_1}$, $\left.\dfrac{dF(x)}{dx}\right|_{x=0} > 0$, $\left.\dfrac{dF(x)}{dx}\right|_{x=1} < 0$, so x = 1 is an evolutionary stable equilibrium point.

Through the analysis of the unilateral stability of the construction enterprises, it is found that $Y=\frac{C_1}{R_1+P_1}$ is the critical point of the X change of the green construction probability. When $Y=\frac{C_1}{R_1+P_1}$, X remains stable; when $Y<\frac{C_1}{R_1+P_1}$, X evolves to 0 and remains stable at this point; when $Y>\frac{C_1}{R_1+P_1}$, X evolves to 1 and remains stable at that point.

3.2 Regulation Probability Threshold Setting

The above analysis reveals the theoretical basis for regulators to set up the threshold of monitoring probability, and gives the setting method of monitoring probability threshold, that is, the regulatory probability corresponding to the mixed strategy equilibrium point E_5 under the static regulatory mechanism.

4. Conclusion

On the basis of the analysis of the current situation of green construction development and supervision, this paper constructs an evolutionary game model and studies the problem of green construction supervision through theoretical analysis. The following conclusions are drawn.

Under the static supervision mechanism, the supervision probability threshold is set up from the perspective of the unilateral stability analysis of the game player. When the probability of regulation is maintained above the regulatory probability corresponding to the mixed strategy equilibrium point, the green construction probability of construction enterprises will evolve to 100%, and has good stability, so as to achieve the optimization of regulatory mechanism.

References

Cai, L. R., Wang, H. W., & Zeng, W. (2009). System Dynamics Model for a Mixed-strategy Game of Environmental Pollution. *Computer Science*, *36*(8), 234-238.

Chen, M., Zhu, Q. C., & Dong, D. M. (2011). Game Study on Construction Safety Supervision Based on System Dynamics. *China Safety Science Journal*, *21*(12), 73-81.

Smith, J. M., & Price, G. R. (1973). The Logic of Animal Conflict. *Nature*, *246*(5427), 15-18. https://doi.org/10.1038/246015a0

Weibull, J. W. (1995). Evolutionary Game Theory. *Southern Economic Journal*, *22*(88), 43-49.

Zhu, Q. H., Wang, Y. L., & Tian, Y. H. (2014). Analysis of an Evolutionary Game between Local Governments and Manufacturing Enterprises under Carbon Reduction Policies Based on System Dynamics. *Operations Research and Management Science*, *3*, 71-82.