

Analysis on the evolution of decision-making behavior of green operation and management subject

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Abstract. In view of the current situation of high energy consumption and unsatisfactory energy-saving effect of existing large commercial office buildings, green operation management is applied to the operation and management process of existing large commercial office buildings. By constructing an evolutionary game model between owners and property management enterprises under market mechanism and government incentive, this paper explores the acceptance degree of owners and property management enterprises to green operation management under different circumstances, as well as their strategic choices and changing trends. Finally, the paper proposes that the government should actively play a leading role and encourage the development of green operation management.

1 Introduction

China is currently in a critical period of industrialization and urbanization, the rapid development of urbanization has led to a significant increase in the area of public buildings, in 2017 China's public building area of about 12.3 billion square meters^[1]. The stock of public buildings is increasing, but the current situation of operation and management of high energy consumption, low energy saving rate and poor indoor environment quality has not been improved. Among the factors that affect the operation and management of large-scale public buildings, energy consumption is the most effective factor. The energy consumption intensity of large-scale public buildings is 2 ~ 4 times that of ordinary public buildings, and the annual energy consumption per square meter is 10 ~ 20 times that of ordinary residential buildings^[2].

The regulations on Green Operation and management of Public Institutions issued by Tianjin Municipality in 2018 pointed out that public institutions should be guided to adopt green operation and management to improve their service level and reduce energy consumption in the operation phase. Green Operation Management is an effective way to achieve the goal of building energy saving of 930 million tce at the end of "Fifteen" period^[3].

2 Green operations management

After thoroughly studies the operation management related policies in China, in this paper, the concept of green operation management is summarized as: to implement the green development concept, through reasonable with green technology and advanced equipment, to save resources, protect the environment, reduce pollution to wear in the whole process of operation

management, to improve building comfort, reduce the energy consumption spending at the same time, to achieve economic, social and environmental benefits of organic unity management process.

2.1 Definition of participants

2.1.1 Owners

The owners of the existing large commercial office buildings are the investors and direct beneficiaries of the equipment related to green operation and management, which is the internal motive force to promote the traditional operation and management to green operation and management upgrade.

2.1.2 Property management

As the executor of building operation and maintenance, property management enterprises are in the dominant position in the green operation and management process. Because of its different nature, so set, property management enterprise is the owner of external employment of the enterprise.

In today's sustainable development, the traditional mode of operation and management has been unable to meet people's growing needs for a better life. Will Save Resources, protect the environment, reduce pollution throughout the operation and management process of green operation and management, the future owners and property management enterprises will be favored^[4].

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3 Analysis on the equilibrium of main body evolutionary game

3.1 Basic assumption

(1) The owner's behavior strategy includes "support" and "not support" Green Operation Management, in which "support" means the owner is willing to pay for the equipment and share the energy-saving benefits; The behavior strategy of property management enterprise includes "providing" and "not providing".

(2) Suppose the proportion of "support" and "not support" is x and $(1-x)$ respectively, and the proportion of "provide" and "not provide" are Y and $(1-y)$ respectively.

(3) It is assumed that the government's incentive to property owners and property management enterprises is Q_1, Q_2 .

(4) The owner and the property management enterprise are bounded rationality, and they can achieve stable game equilibrium through continuous study and adjustment^[5].

3.2 Parameter setting

(1) When choosing general operations management

M_1 : Normal income of the owner; M_2 : Normal income of property management enterprises

(2) When choosing green operations management

C_1 : Incremental costs to owners; C_2 : The incremental cost of property management enterprises; R_1 : Green operation and management of the total incremental revenue, mainly refers to energy-saving revenue; β : Property owners to property management enterprises share of energy-saving income ratio; R_2 : The property management enterprise finally obtains the total increment income.

Under the market mechanism, the benefit matrix of owners and property management enterprises choosing green operation management development game is shown in Table 1.

Table 1 Benefit matrix of evolutionary game between owner and property management enterprise under market mechanism

owner's property	provide	not provided for
support	$(M_1 + R_1(1 - \beta) - C_1, M_2 + R_2 - C_2)$	$(M_1 - C_1, M_2)$
nonsupport	$(M_1, M_2 - C_2)$	(M_1, M_2)

3.3 Dynamic analysis of owner decision replication

The expected benefits of owners supporting and not supporting green operation management are respectively E_1 、 E_2 , replicating dynamic equation $F(x)$:

$$F_1(x) = x(1-x)[yR_1(1-\beta) - C_1] \quad (1)$$

$$F_1(y) = y(1-y)[xR_2 - C_2] \quad (2)$$

Owner's evolutionary steady state point: $x_1=0$,

$$x_2=1, y^* = \frac{C_1}{R_1(1-\beta)}$$

3.4 Dynamic decision-making analysis of property management enterprises

The expected revenue of property management enterprises to provide and not to provide green operation management services is E_1 、 E_2 . The replication dynamic equation is $F(y)$:

$$F_1(y) = y(1-y)[xR_2 - C_2] \quad (3)$$

$$F_1'(y) = y(1-y)[xR_2 - C_2] \quad (4)$$

Evolutionary stable state point of property management enterprise: $y^1=0, y^2=1, x^* = \frac{C_1}{R_2}$.

3.5 Analysis on the evolutionary stability of strategies of participants

The critical boundary of evolutionary convergence state is formed by $(1,0)(x^*, y^*)$ and $(0,1)$. The decision of the two on the upper right of the polyline evolves into the choice of green operation management. At the lower left of the fold line, both decisions evolve to not choose green operation management. According to the analysis, under the market mechanism, the enthusiasm of owners and property management enterprises to choose green operation management is affected by the amount of possible incremental income and the strategies of the other party.

4 The evolutionary game between the owner and the property management enterprise under the government incentive

Because the green operation management has the economic externality characteristics, in addition to participate in the main body of benefits, also brings to the society such as reducing carbon emissions and boost green operation management related industry development benign influence, so the government should play a guiding role, take certain incentives to make the internalization of external benefit, strengthening operation management main body choice green power.

The benefit matrix of owners and property management enterprises is shown in Table 2.

Table 2 Benefit Matrix of evolutionary game between property owner and property management enterprise

owner's property	provide	not provided for
support	$(M_1 + R_1(1 - \beta) + Q_1 - C_1, M_2 + R_2 + Q_2 - C_2)$	$(M_1 + Q_1 - C_1, M_2)$
nonsupport	$(M_1, M_2 + Q_2 - C_2)$	(M_1, M_2)

4.1 Evolutionary game replication dynamic equation

$$F_1(x) = x(1-x)[yR_1(1-\beta) + Q_1 - C_1] \quad (5)$$

$$F_1(y) = y(1-y)[xR_2 + Q_2 - C_2] \quad (6)$$

$F_1(x) = 0, F_1(y) = 0$, evolutionary game equilibrium between property owners and property management firms under government incentives: (0,0) (1,0) (0,1) (1,1) (x^*, y^*) , $x^* = \frac{C_2 - Q_2}{R_2}, y^* = \frac{C_1 - Q_1}{R_1(1-\beta)}$.

4.2 Discussion of equilibrium points

- (1) $Q_1 + R_1(1-\beta) > C_1$ and $Q_2 + R_2 < C_2$

Both the owner and the property management firm have an incremental return less than their incremental costs, at which point (0,0) is the ESS point. When the owners and property management enterprises get less than the cost, they will eventually give up the choice of green operation and management.

- (2) $Q_1 + R_1(1-\beta) > C_1$ and $Q_2 + R_2 > C_2$

The strategy choice of the owner, the choice appears to diverge but eventually both evolve to give up to choose the Green Operation Management.

- (3) $Q_1 + R_1(1-\beta) < C_1$ and $R_2 > C_2$

The Property Management Enterprise, the strategy choice appears the difference but ultimately evolves does not provide the Green Operation Management Service, the owner chooses not to support the Green Operation Management.

- (4) $Q_1 + R_1(1-\beta) > C_1$ and $Q_2 + R_2 > C_2$

Both the owner and the property management firm have an incremental return greater than their incremental costs, which produces two stable points (0,0) and (1,1) .

The evolutionary phase diagram of the above conclusions is shown in Figure 1 and Figure 2.

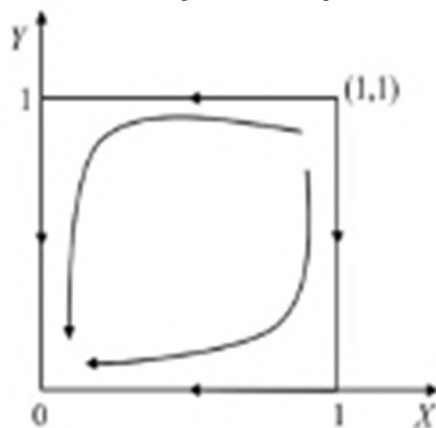


Fig. 1. Conclusion 1-3 evolutionary phase diagram

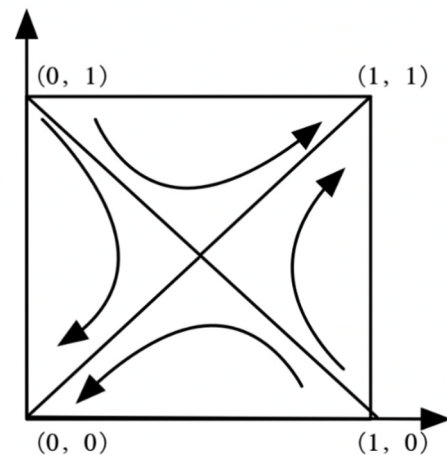


Fig. 2. Evolutionary phase diagram of Conclusion 4

5 Conclusion

Using the evolutionary game theory, this paper analyzes the evolutionary game behavior of property owners and property management enterprises respectively. Through analyzing the conditions for existing large commercial office building owners and property management enterprises to choose green operation and management under government incentives, the following suggestions are put forward:

First of all, the government should play a guiding and regulating role and formulate reasonable incentive policies, such as preferential tax policies and financial support. In addition, the government can provide financial support and preferential loans for green technology R&D and production projects that meet the requirements. In addition, we should give full play to the role of the market in resource allocation, establish a market-oriented green operation and management mechanism, promote enterprise technological innovation and service innovation, improve service ability and improve service quality.

Secondly, we should strengthen the construction of green operation and management talents, improve the professional quality of managers, and provide necessary training for managers to provide technical support for green operation and management. The innovation of technical talents within enterprises can be encouraged, and the technological research and development can be promoted by setting incentive measures, reward and punishment systems, and the transformation of technological achievements can be promoted.

Finally, we should intensify publicity on green operation and management, raise people's awareness of green operation and management, create an environment for enterprises that adopt traditional operation and management, regulate pressure, and increase the training of relevant technical and managerial personnel, to improve its executive ability and efficiency.

References

1. Building Energy Efficiency Research Center, Tsinghua University. China building energy efficiency annual development research report 2019[M]. Beijing: China building industry press, 2019.
2. Interim Measures for the Administration of Special Funds for Energy Conservation in State Office Buildings and Large Public Buildings [J]. Construction supervision, testing and cost, 2008, 1(2): 1+3.
3. NIE L, ZHANG L J. Evolutionary Game Analysis and Simulation between Government and Pollutant Enterprises in Green Technology Innovation [J]. Economic problems, 2019(10): 79-86.
4. HUO Y. Research on operation incentive mechanism of large green public buildings [D]. Xi'an: Xi'an University of Architecture and Technology, 2017.
5. ZHAO Q Q, GUO H D. Research on incentive mechanism of existing building energy saving reconstruction based on principal-agent [J]. Journal of Tianjin Chengjian University, 2015, 21(6): 428-432+458.
6. XU J Z, LV X S. Study on the evolution of decision-making behavior of government, manufacturing enterprises and consumer groups under the low carbon economy [J]. Operations research and management, 2014, 23(6): 81-91.
7. Bo B. Discussion on Green Operation Mode of Retailers from the Perspective of Green Consumption [J]. Commercial economics research, 2017(4): 97-98.