Research on Energy-Efficient Buildings Investment Incentive Policy Based on The Asymmetric Game Theory

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Abstract

In order to encourage the real estate developers to develop energy-efficient buildings more actively,This paper uses asymmetric game theory to establish a government incentive policies model,by analyzing the government and real estate developers Game questions on the interests of energy-efficient buildings and analyzing the game equilibrium to put forward some Suggestions of improvement of energy-efficient buildings investment incentive policy.

Keywords

Government, real estate developers, energy-efficient buildings, incentive policies, game analysis.

1. Introduction

The energy issues are key issues to be solved in the sustainable development of our country, but the building energy consumption has accounted for about 45% of the energy society terminal consumption. The reduction of energy consumption of building will play an important role in energy conservation and emissions reduction. For governments, therefore, building energy-efficient buildings is the guarantee of national energy security, protecting the environment, improving people's living quality, and major measures for construction of saving type society. But at present, energy-efficient buildings mainly depending on the design of the mandatory standards implement passively. Frequently, real estate developers driven by interests and in order to ensure that cost savings consciously reduce energy-saving measures in the aspects such as land development, design, construction and commissioning, it eventually lead to energy saving measures does not reach the designated position, and the effect is not significant. This kind of dilemma in addition to real estate developers own quality is not high, the lack of strong government incentive policies to promote the development of energy-saving building is also another important factor. This article will take the game theory as the theoretical tools, analysis the game relation between government and developers. The results will help to provide theoretical basis in setting reasonable incentives policy for energy-efficient buildings.

2. Players in the game of Energy-Efficient Buildings and the analysis of the interests of the parties

2.1 Game players

In this game, we assume that only two players: government and real estate developers. This is because real estate developers is the decision-making body of implement energy-efficient buildings. It is bound by the provisions of relevant government mandatory and guided by incentive policy, meanwhile, it is affected by the housing demand of the customers; Consumers through the market mechanism to developers influence investment decisions, at the same time, it was led by the government macro policy. However, the developer’s investment decisions before the consumer's purchase decision, That is to say, the decision-making is not the beneficiaries and direct incentives to consumers will be difficult to work in the short term. Therefore, at present, the relevant policies of the government should be mainly to encourage developers.

2.2 The basic hypothesis of game

(1)The government is fully rational decision-makers ,its goal is to achieve maximum energy efficiency; The developers is bounded rational decision-makers ,bounded rational players is not necessarily able to find the optimal strategy at first, but they are adjusted by learning process, and finally reach the equilibrium of evolutionary game.

(2) In the repeated game of "bounded rationality", evolutionary stable equilibrium must be achieved by the process of imitating, learning, and adjustment of the participants. This equilibrium can be subjected to errors and deviations which is caused by bounded rationality, and the equilibrium still able to recover after a small amount of interference. We can use the replicator dynamics equation to simulate the **t** times repeated game between the government and developers.

(3) Information is asymmetric between the government and the real estate developers. The government fully aware of construction costs and benefits of energy-efficient buildings, while developers are not, so the government can guide the developers to participate in building energy saving houses by some action.

(4)For real estate developers, the government has two policy options: incentive policy and non-incentive policy; Developers also have two strategies, namely, to construct energy-efficient building and to construct non- energy- efficient buildings.

3. Game model of constructing energy-efficient buildings.

(1) Game model

The game relationship between government and real estate developers whether to construct an energy-efficient building under the condition of the presence of incentives as shown in figure 1 ,the game tree model. Pi (i=1,……, 8)on behalf of the government or the developer's final payoffs.

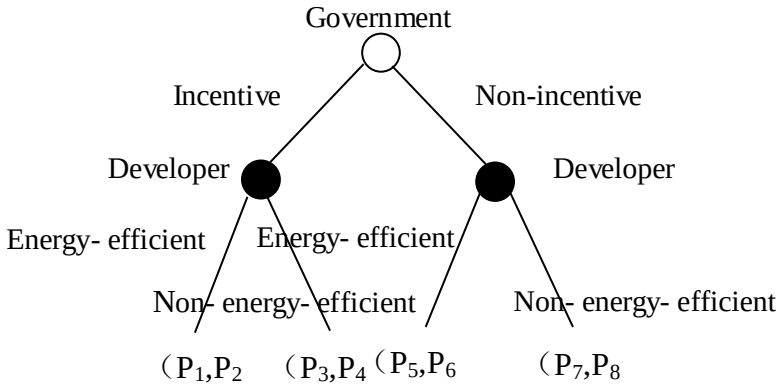

Figure 1. The game model between government and real estate developers

(2) The hypothesis of game model parameter

A: The government's revenues;

A1 on behalf of government's revenues for developers to construct energy-efficient buildings; A2 on behalf of government's revenues for developers to construct non- energy- efficient buildings.A1>A2;

B: The developer's incomes;

I1 on behalf of developer's incomes for constructing energy-efficient buildings; I2 on behalf of developer's incomes for constructing non- energy- efficient buildings.

C: Cost of government incentive policies;

D: The increased cost of developers to construct energy-efficient buildings;

E: The received awards of developers to construct energy-efficient buildings;

F: The punishment of developers to construct non- energy-efficient buildings;

(3)Payoffs

According to the hypothesis of game model parameter and the game model, government and developers of the final payoffs were P1=A1-C-E, P2=B1-D+E, P3=A2-C+F, P4= B2-F, P5=A1, P6=B1-D, P7=A2, P8= B2.

(4)Payoff Matrix

Assume that the probability of the developers to construct energy-efficient buildings is x; the probability of the developers to construct non-energy-efficient buildings is 1-x; the probability that the government takes the incentive policy is y, and 1-y is the probability that the government takes the non-incentive policy. Depending on the above assumptions can get payoff matrix is shown in figure 2.

		Developers	
		energy-efficient buildings (x)	non-energy-efficient buildings (1-x)
Government	incentive policy (y)	A1-C-E, B1-D+E	A2-C+F, B2-F
	non-incentive policy (1-y)	A1, B1-D	A2, B2

figure 2 Payoff Matrix

4. Game analysis of constructing energy-efficient buildings.

4.1 Game analysis of developers

Expected return and the dynamic equation

According to the payoff matrix, the developer's expected return is as follows:

(1) Expected return of constructing energy-efficient buildings: G11= (A1-C-E) y+ A1 (1-y);

(2) Expected return of constructing non-energy-efficient buildings: G12= (A2-C+F) y+ A2 (1-y);

(3) The average expected return of developers: G1= G11x+ G12 (1-x).

So, the developer’s replicator dynamics equation is

H(x)==x(G11- G1)=x(1-x)[(A1- A2) - (E+F)y],let $\frac{dx}{dt}$=0,get x1=0,x2=1,y*= $\frac{A_1 - A_2}{E + F}$.

According to the stability theorem of differential equations and the nature of the evolutionary stable strategy, when H’(x)<0, x is evolutionary stable strategy.

Game analysis from the perspective of the developers

When y*= (A1-A2)/(E+F),H(x) is 0,That is, the government incentive policy support (initial probability) reaches y *,the initial ratio of the developer to choose energy-efficient buildings or not is stable;

When y>y*, H’(0)>0, H’(1)<0, x2=1 is the only evolutionary stable strategy, that is, the developers choose the strategy of developing energy-efficient building benign interaction with the government's incentive policy, gradually achieve the pare to optimality condition.

When y<y*, H’(0)<0, H’(1)>0, x1=0 is the only evolutionary stable strategy, that is, when the government's incentive policy of building energy-efficient buildings is not strong enough, construction of non-energy-efficient buildings will be the choice of developers instead of building energy-efficient buildings.

4.2 Game analysis of government

Expected return and the dynamic equation

According to the payoff matrix, the government's expected return is as follows:

(1) Expected return to take incentive policy: G21=(B1-D+E)x+ (B2-F)(1-x);

(2) Expected return to take non-incentive policy: G22=(B1-D)x+ B2 (1-x);

(3) The average expected return of government: G2= G21y+ G22(1-y).

So, the government replicator dynamics equation is

$I(y)=\frac{dy}{dt}=y(G21-G2)=y(1-y)[(E+F)x-F]$, let $\frac{dy}{dt}=0, y1=0, y2=1, x^*=\frac{F}{E+F}$.

Game analysis from the perspective of the government

When x*=F/(E+F), I(y) is 0,That is, the initial ratio of the developer to choose energy-efficient buildings reaches x*,the probability of incentive policy implemented by the government is stable;

When x>x*, I'(0)>0, I'(1)<0, y2=1 is the only evolutionary stable strategy, that is, the developers choose the strategy of developing energy-efficient building benign interaction with the government's incentive policy, gradually achieve the pare to optimality condition.

When x<x*, I'(0)<0, I'(1)>0, y1=0 is the only evolutionary stable strategy, that is, when the government's incentive policy of building energy-efficient buildings is not strong enough, construction of non-energy-efficient buildings will be the choice of developers.

5. Conclusion

(1) For the government, the energy-efficient buildings incentive policy should focus on the following aspects:

Make full use of the advantages of the various resources to maintain high rationality of the government and to build the integrity of the government; By strengthening the construction energy conservation publicity to raise awareness of building energy efficiency and effectively reduce the cost of carrying out the policy, in other words, the government should take measures to reduce the incentive policy starting point and the popularization of energy-saving building critical point y * and x *.

The government should implement incentive promised to strengthen incentives to increase the value of E and increase compensation for developers to build energy-efficient buildings; Meanwhile, the government should improve the punishment mechanism, reasonable grasp the proportion of rewards and punishments, which increase the F and reasonable distribution of the size of the E and F relationship;

Government should encourage enterprises to actively introduce the advanced energy saving technology, reduce the cost of building energy-efficient buildings and the profit margin between the construction of energy-efficient construction and non - energy - efficient construction.

(2) For the developers, what should they do is to actively respond to the incentives and focus on the following:

Pay close attention to the political, economic, and social and other aspects of the dynamic information, constantly improve their rational level;

Positive response to the government of building energy saving incentives, fully enjoying the preferential policy of E, reducing the occurrence of punishment F;

Enterprises should change energy saving ideas, and actively introduce advanced energy saving technology, establish green brand image to improve their competitiveness.

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