Journal of Theoretical and Applied Information Technology
10th March 2013. Vol. 49 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

SUBSIDY MODEL DESIGN OF GREEN BUILDINGS BASED ON GOVERNMENT BENEFITS

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ABSTRACT

This paper carries a deep analysis on the cost and economical attributes of green buildings, and points out that in order to promote the development of the green building market, the government should motivate the property developers by maintaining a balance in the profits among the project participants, apart from the necessary supervision and constraint. This paper defines all the parameters that have effect on the development of the green buildings and establishes a subsidy model, regulates the supervision of the government and incentive system, and maintains a balance between them. Finally, a specific combination scheme of government expenditure is put forward in this paper and is explained further by example.

Keywords: *Project Management, Green Building, Supervised Cost, Incentive Cost, Subsidy Model*

1. INTRODUCTION

From the 1997 Kyoto Conference to World Climate Change Conference held in Copenhagen 2009, scholars around the world have generally concerned about the protection of the global energy environment. As a special commodity, architecture's impact on the natural environment should not be underestimated.

In 1990s, our country introduced the concept of green building. In March 7th 2006, Ministry of Construction gave a new definition for "green building" through "Evaluation Standard of Green Building". It is the architecture that, under the suitable conditions, can maximize conservation of resources (energy, land, water and materials) in the whole life cycle of building. It can also protect the environment and reduce pollution to provide people with safe, healthy, and applicable use of space, coexisting with nature in harmony [1]. Domestic research in the field of green building started late. Many theories and policies are not perfect enough. China has successively promulgated several rules and regulations since 2001, and will promote the construction of green buildings as a national mandatory comprehensively in the country. But currently, many developers haven't promoted the green building with a positive attitude. There are still acts of cutting corners, reducing the design standards in the course of specific implementation of the regulations, thus making the green of the green building unable to meet the requirements and making little and slow progress in the related work.

The research of the global researchers mainly focuses on the following aspects: firstly, a thorough analysis of the total cost in the whole process including the designing and the construction of the building is conducted. And it points out that the green building has a dramatic impact on the saving of the total cost [2]-[5]. Secondly, based on the External Economic Theory and Game Theory, a thorough analysis of the distribution of the profits of the investment of the green building among government, developers and consumers is carried out. It points out the necessity of formulating incentive system and advancing constructive suggestions in policy-making [6]-[9]. Thirdly, based on the Evolutionary Game Theory, it formulates the governmental incentive system and advances constructive suggestions in policy-making [10]-[12].

In conclusion, as a public interest sector, government has the coercive power and effectiveness that are empowered by the country and its people, but it is still necessary to regulate the degree of the government supervision and incentive system reasonably. This paper uses the incentive method of government subsides. It analyzes the perspective of the social benefits of full life cycle of green building. It maintains a

balance of the profits among all parties involved in the project through the model of government subsides, so as to maximize the profits of government while it promotes the green buildings.

2. COST-BENEFIT ANALYSIS OF GREEN BUILDING

It is obvious that green building has more economic advantages than ordinary building in that the former has a lower operation cost , a longer operating life and saves much more energy. But because of its own characteristics and some external factors, the green building requires more initial investment and the recovery of interest is rather slow. Not only is the long-term reward not obvious, but also it is shared by the community and all users, which makes many developers reluctant and powerless to build green building and retards the development of green building market. In this paper, a detailed analysis of the cost and benefit is carried out for the developers, the consumers and the government.

2.1. Cost Analysis Of Green Building

The cost of green building during its life cycle includes decision-making costs, construction costs and operation and maintenance costs.

The developers are responsible for undertaking decision-making costs, construction costs. In view of saving energy and according to the needs of construction, we need to install green energy equipments and use green materials, just like pervious concrete, concrete is compatible with plants, renewable concrete, care antibacterial tile, Low-E coated glass, inorganic activity wall insulation materials, expanded polystyrene plastered wall. In addition, except the existing technology, new innovative technology has also been introduced into the construction of the green building. So engineers, technicians and production workers are required to have the relevant training before construction. As a result, all these make the construction costs of green buildings slightly higher than ordinary construction.

Consumers who are the users of green building are mainly responsible for maintenance costs, management costs, energy costs, resource costs and environmental costs while having the possession of the green building. Because of the energy efficiency of green building, the use of cost of green building for consumers is lower than ordinary construction.

In the development process of green buildings, the government mainly undertakes the social, economic and ecological environmental loss caused by the activities of green buildings in the life cycle, the loss mainly includes environmental, administrative and scrap cost. Green buildings have ecological environmental benefits, architectural life rubbish and environmental pollution produced in construction and use process have been reduced greatly. Furthermore, government environmental and scrap cost are relatively low. Government administrative cost mainly refers to the government's supervision and incentive cost.

Currently, our country depends on government supervision to control the market order, so it does not have sufficient information basis and implementation effect. Information asymmetry causes green buildings market barriers, the government must take incentive policies to promote the development of green buildings in China. The government supervision cost includes: 1）Setting the supervision system-according to the characteristics of green buildings, government sets supervisory organ, trains and selects specialized person to be engaged in the work and formulates supervision rules; 2 ） Supervising the implementation-in different stages of the project implementation, the government supervision departments need to organize experts to examine and verify construction sites and technical materials. This requires a lot of investigation and data analysis. For some specialized fields, it needs experts to analyze and assess. The government has many incentive methods, including explicit and implicit incentives, such as tax cuts, accelerated depreciation, levying a new tax, low-interest loans, cash discount and bonus, government procurement, mortgages, research funds, resources agreement. But no matter which way is adopted, it will generate incentive costs. This paper uses government cash discount and bonus way to create model, and carries out the research.

2.2. Green Buildings' Benefit Analysis

Green buildings belong to external economic product, they have certain public goods attributes and positive economic externalities, they can produce income in their whole life cycle, and different benefited parties enjoy the indirect earnings brought by green architecture in each stage.

For government and consumers, green buildings' maintenance cost reduction, energy saving and environmental cost reduction in use process are long-term indirect benefits.

For developers, their main income is the sale price higher than ordinary buildings' after the completion of the project. But the green concept of the consumers in our country is not strong, except a few experts and researchers who really realize the meaning of green buildings, while most people do not. For most consumers, due to general low income, they tend to buy ordinary buildings of lower prices. In this market economy, developers are social economic groups which are in pursuit of profit, they won't raise the price too high to lower their market competitiveness; and they won't compress their profit space to promote green buildings. As shown in figure 1：

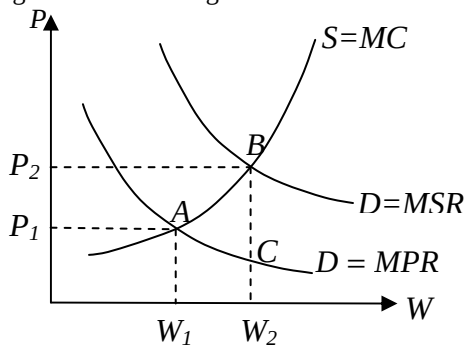

Fig1. Analysis Chart Of Green Buildings' Economic Externalities

Prefers to the price of the green building (price), M refers to the green building quality, namely building energy-saving degrees. Under the market regulation, the supply curve of green buildings is decided by the developers' marginal cost(MC),from the angle of the overall social benefits, the demand curve of green product depends on social marginal remuneration(MSR), when MSR and MC fellowship in B, the supply of green buildings for society by developers and the demand of green building by the whole society achieve a balance, the corresponding energy-saving degrees of green buildings reach the social optimality at this time. But due to the existence of green building external benefit, developers make decisions without considering social marginal remuneration, the energy-saving degree W is decided by intersection A of developers' internal marginal remuneration and marginal cost to implement construction. Right now social income does not achieve Pareto optimality, in the short term, developers can't deserve gains through market regulation, which indicates that the market regulation has failed.

Green building earnings are shared by the society, it is unfair to any party to undertake the incremental cost alone, and the government should formulate reasonable supervision and incentive policy and maintain a balance of the profits of each party.

3. BUILDING HYPOTHESES OF THE MODEL

According to the analysis of the cost-benefit of green architectures in our country, it can be seen that the developing pattern of green architectures is still slow in China as a result of its high cost during construction period and their characteristic of social sharing with their returns to investments, in spite of their social benefits. China only accounts for 5 percent of the total green architectures. As far as this problem is concerned, this paper plans to use incentive policy that gives certain allowances to the incremental cost of green architectures based on original government supervision. In this way, we are able to build model of subsidies aiming at maximizing the benefits of governments which goes for the balance point of supervisory strength and incentive strength.

The model is established with government's point of view and aimed at guaranteeing the government's operating efficiency which means using cost as low as possible to reach the best effects.

There are two choices for developers when developing construction projects-green architectures and ordinary ones, so two corresponding behaviors involve endeavor and speculation which occur during the development of projects in corresponding with the choices. We signify the two behaviors with k_1 and k_2 respectively. On one hand, if the developers select efforts behavior k_1 which stands for more efforts to the green architecture during the constructing period, the income of the project is $R(k_1) = k_1 + \theta$, on the other hand, if they select speculative behavior k_2 which shows their tendency to ordinary buildings with the income of $R(k_2) = k_2 + \theta$.

The economic benefits and long-run performances of resources, environment and society which green architectures bring about can be signified with $R = k_1 - k_2 + \theta$. $\theta \sim (\mu, \sigma^2)$ is an exogenous variable which refers to the uncertainly effects to the project earnings caused by external factors. As a result, we can use $R(r_0) = r_0(k_1 - k_2 + \theta)$ which refers to the developer' extraneous income that includes brand value (reputation income) and higher price when

exploiting the green architectures. Green income coefficient r_0 means the proportion of the developers' extraneous income which comes from green architecture. The government's subsidy is $W = w_0(k_1 - k_2 + \theta)$ and w_0 means government incentives dynamics.

Because the cost function is monotonically increasing convex function of variables, $C(p)$ (government oversight cost function) has to meet the condition that $C'(p) > 0$, $C''(p) > 0$. We assume that government oversight cost function is $C(p) = \frac{1}{2} c_0 p^2$, c_0 refers to government oversight cost coefficient. Here p means stringency of government oversight, and it's equal to the probability that developers' speculative behavior can be found. Punishment strength to the developers who don't implement of energy efficiency standards is $L(k_2) = pfk_2$, and f means punishment strength coefficient.

Similarly with Previous paragraph, developer effort cost is $C(k_1) = \frac{1}{2} c_1 k_1^2$, and c_1 means effort cost coefficient. At the same time, developers' cost of speculating is $C(k_2) = \frac{1}{2} c_2 k_2^2$, c_2 means speculating costs.

Developers' profit= extraneous income of green architecture developers+ income of ordinary buildings + government subsidy –struggling cost - speculative cost-punishment.

Government's profit= income of green architecture + punishment-supervision cost-government subsidy.

With the assumptions by subsection 2.1, the profit function of the developers and governments can be signified to be:

$$\pi_d = R(r_0) + R(k_2) + W - C(k_1) - C(k_2) - L(k_2) \quad (3\text{-}1)$$

$$\pi_g = R(k_1) + L(k_2) - C(p) - W \quad (3\text{-}2)$$

π_d - Developers' profit; π_g - Government's profit.

Using parameter by substitution into equation 3-1, we can get the largest expectation of Developers' profit.

$$\max E(\pi_d) = r_0(k_1 - k_2 + \mu) + k_2 + \mu + w_0(k_1 - k_2 + \mu) - \frac{1}{2} c_1 k_1^2 - \frac{1}{2} c_2 k_2^2 - pfk_2 \quad (3\text{-}3)$$

Getting partial derivative in equation 3-1 separately

$$\frac{\partial E(\pi_d)}{\partial k_1} = r_0 + w_0 - c_1 k_1 = 0 \quad (3\text{-}4)$$

$$\frac{\partial E(\pi_d)}{\partial k_2} = -r_0 + 1 - w_0 - c_2 k_2 - pf = 0 \quad (3\text{-}5)$$

The best behavior combination is

$$\{k_1^*, k_2^*\} = \{\frac{r_0 + w_0}{c_1}, \frac{1 - r_0 - w_0 - pf}{c_2}\}$$

Using parameter by substitution into equation 3-2, we can get the largest expectation of Government's profit.

$$\max E(\pi_g) = k_1 + \mu + pfk_2 - \frac{1}{2} c_0 p^2 - w_0(k_1 - k_2 + \mu) \quad (3\text{-}6)$$

Substitute it into $\{k_1^*, k_2^*\}$ and get partial derivative in equation 3-6 separately for w_0 and p, then we can get

$$\{w_0^*, p^*\} = \{\frac{1 - r_0}{2} - \frac{c_1\mu(2f^2 + c_0c_2)}{2(2f^2 + c_0c_2 + c_0c_1)}, \frac{c_1\mu f}{2f^2 + c_0c_2 + c_0c_1}\} \quad (3\text{-}7)$$

Equation 3-7 is just the best combination scheme of incentives strength and supervision of government.

4 CASE STUDY

The total cost of a certain green construction department houses project is 3.4 billion. The total land area is 659658m^2, composed of nine point blocks and four multilayer terrace-backwards buildings with a total construction area of about 163853m^2, the plot ratio is 2.0, and green space rate is 41.5, The total households are 1251, the per capita land index is15.06m^2, and the per capita area of public green is 3.645m^2.

The green building design of the projects uses a passive energy-saving technology; high efficiency, energy-saving materials, equipment and systems, uses renewable energy, rainwater reuse and reclaimed water etc. and it is strictly designed according to the two star standards in the <<GB/T50378-2006 Green Building Evaluation Criteria>>. Such factors as topography, climate, environment and region are taken into consideration in design. Traditional and local technology is

preferred in order to optimize the composition of the incremental construction. For the specific data of this residential area green building cost increment please see the table 1 [13].

Table1.Construction Cost Increment Constitution Of A Green Construction Department Houses Project

No.	Technology used	Unit price （Yuan）	Common technique	Unit price （Yuan）	Quantity	Units	Green cost （Yuan）	General /common Cost (Yuan)	Total increment of each individual (Yuan)
1	Aerated Concrete Block	58.9	Normal concrete hollow block	26.22	33000	m^2	1943700	865260	1078440
2	Adjustable blinds built-insulating glass	1050	General Aluminum single glazed windows	220	6726	m^2	7062300	1479720	5582580
3	Pervious ground	60	Common Ground	35	10950	m^2	657000	383250	273750
4	Save-water faucet	25	No	0	1269	household	31725	0	31725
5	Water-saving pedestal pan/ Water-Saving Toilet	500	No	0	1269	piece	634500	0	634500
6	energy saving lighting of Floor Channel and road of the Community	55	General Lighting	15	1872	piece	102960	28080	74880
7	Solar Lighting	1000	None	0	12	piece	12000	0	12000
8	Solar water heater	5000	None	0	84	piece	420000	0	420000
9	air-source heat pump water heater	6000	None	0	706	household	4236000	0	4236000
10	renewable energy elevator	301000	General Elevator	295000	44	unit	13244000	12980000	264000
11	Constructed Wetland wastewater treatment technology	880000	None	0	1	piece	880000	0	880000
12	Micro-irrigation system	25	None	0	27375	m^2	684375	0	684375
13	Waste disposer	250000	None	0	2	piece	500000	0	500000
14	One key to close	50	None	0	1269	household	63450	0	63450
15	East-west wall of heat insulation mortar	58	Cement mortar	13	2975	m^2	172550	38675	133875
16	Intelligent Systems						4500000		4500000
17	others						500000		500000
	Total						**35644560**	**15774985**	**19869575**

From table 1, by adopting the green technology, the cost of the developers increased by RMB 1987 million (RMB), so the developer struggling cost $C(k_1) = 19869575$, According to the formula $C(k_1) = \frac{1}{2} c_1 k_1^2$, the developer struggling cost coefficient $c(k_1) = 3.44 \times 10^{-10}$.

Despite green building incremental cost, the common project construction cost is 3.2 billion RMB. Assuming the speculative cost of enterprises accounts for 3% of the project cost, $C(k_2) = 3\%k_2$, then according to the formula $C(k_2) = \frac{1}{2}c_2 k_2^{\ 2}$, the developer speculative cost coefficient $c_2 = 1.875 \times 10^{-10}$.

According to the "Regulation on Civil Building Efficiency" established in Oct. 1st, 2008, the construction projects not following the energy conservation standard will be imposed fines of 2% of the developer project sales. The action object of parameter f is developer cost, so parameter f=2.4%. The greening building cost increment mostly are around 6% in China, because green technology leads to a higher house price, the acceptable floatation degree is less than 3%, plus the reputation gain of developers, the extra income coefficient of developers r0=60%.

The cost coefficient of government's supervision takes the value of 0.5 percent of engineering building cost. The average profit margin of real estate industry takes 20 percent of the construction cost. So,

$$c_0 = 1.7 \times 10^6, \mu = 6.8 \times 10^7$$

According to formula 3-7, to get the optimal combined scheme of government's supervision and encouragement, that is, as follows:

$$\{w_0^*, p^*\} = \{0.1923, 0.2746\}$$

The optimal subsidies of the government is 19.23 percent of the project's green incremental cost, namely the government should use various economic methods, such as tax reliefs, low-interest loans, resource agreements and so on, to give economy subsidies RMB3,820,919 to the construction developer. Meanwhile, the government is suitable to invest RMB 64,094 to build a government group which is devoted to supervising the project during the whole building process.

5 CONCLUSIONS

Based on the analysis of the cost and benefit of green buildings, focusing on the period of short-term, this paper sets up a compensation model, which can optimize the interest sharing among the developers, the consumers and the government and promote the boom of China's green building market. But, taking into consideration the market's long-term development, the government should adopt the macro-control to improve social environment of green buildings' demands and increase the share of developers in the green building additional benefits. Meanwhile, it is necessary to reasonably arrange the work of government supervision and reduce the cost coefficient of government supervision to make the government's cost, supervision and incentive dynamics down. With the deepening of social green concept, the government's incentives should be gradually faded out.

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