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Economic Cost-benefit Analysis of Green Building Based on the Low-carbon Economic Policy

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Abstract: The main policies in a city to deal with climate change are to promote energy saving, the reduction of carbon emission, and the construction of green building, which is also a kind of governance mechanism within the legal city planning and construction management system. However, in some areas, a lot of local governments and urban construction enterprises are still misunderstanding the concept of green building, especially in the application of low carbon technologies which may make some impact on the economic cost. At present, in this field, the discussion of the policy making is mainly aiming at the problem of technology application. As a decision maker or investor, it is essential to know the real meaning of green building and its economic efficiency. This paper makes an analysis on the current policy of green buildings and establishes the cost-benefit analysis method of green building based on the theory of property rights from a macro perspective, then points out that it is necessary to design a set of operational analysis tools for the project level, and should put the benefits of green building construction in a macro economy level. Green building with incremental costs will bring additional incremental investment, which will lead an additional increase in industrial output during the economic system, and thus will have a macro impact on the overall economy in turn.

Key words: green economics, cost-benefit analysis, green building policy

1. Introduction

Climate change is the biggest and most controversial environmental issue at present. For its profound impact on the existence and development of mankind and as a major challenge faced by all countries, the world now mostly agrees that something needs to be done about global warming and climate change. On 12 December, 2015, Le Bourget, Paris, the historic Paris agreement on climate change is finally adopted with no objection at the COP21 [1]. After signed the Paris Agreement, China was energetically exploring for low-carbon development pathways [1].

The main policies in a city to deal with climate change are to promote energy saving, the reduction of carbon emission, and the construction of green building, which is also a kind of governance mechanism within the legal city planning and construction management system. In building industry, how to promote green building has become a central issue in the development of low-carbon city [2, 3]. In order to promote more people to develop green building, it is important to create people's green building consciousness and follow the low-carbon city development policy [4].

With the promotion of building energy-saving and the establishment of certification system in green building standards, the extra cost and benefits in the process of green building design and construction has been concerned with [5, 6]. An analysis of 33 buildings in California's green building economic indicators pioneered the trend of analyzing the United States of green building cost [7]. After that, the United States Federal General Services Administration conducted a survey and made an analysis about the additional cost needed to be paid if the newly built or rebuilt project could achieve LEED certification [8]. After that, there are many researches were conducted on the green

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building additional cost problem, and those all pointed to that there is a little or none additional cost in the basic grade certification [9, 10]. Green Building Council of Australia firstly published the economic analysis of green building, which made a comprehensive description about business model of green building and market considerations [11]. In 2010, they suggested that the government should establish a perfect financial incentive and all the commercial buildings should offer their energy consumption efficiency [12]. For the government of United Kingdom, green building cost analysis of market impact is main policy basis of continuous promotion of standards of green buildings [13]. In China, the economic evaluation method of construction project was mainly divided into "financial evaluation" method and "economic evaluation" method [14], which does not highlight the characteristics of cost and benefit of green building. Some researches put forward the principle of increment cost of green building [15] and also cited the concept of green GDP [16], which put forward the use of the method of difference comparison to evaluate the index which was divided into the cost incremental index and benefit incremental index, thereby reducing the cost of green building and promoting the implementation of green building.

From the above researches, we can see the development and some achievements on the economic efficiency of green building construction policies and relevant technical standards. However, the existing research still has some weaknesses: they are mainly focus on the content of the specific economic data analysis, focusing on the technical level of discussion, but are lack of economic efficiency from the basic economic theory to understand the green building policy. Green building policy is a part of low-carbon urban planning and construction system, so we need to analyze how to understand the efficiency of the policy from the perspective of economic theory. Moreover, as a decision maker or investor, it is essential to know the real meaning of low-carbon green building and its economic efficiency.

2. The Analysis of Current China's Energy Conservation Policy on Green Building

2.1 The Government Restriction Policy System of China's Building Energy Conservation

The government restriction method intervenes directly in the allocation of market resources or changes indirectly the supply-demand relationship between producer and consumer through law and administrative regulation. At national level, it depends on the way of "from top to the end" to develop, and there are five gradations of legal system, including law, administration regulation, ministry rules, policy oriented document, standard specification and technical directives, which is to develop a legal basement for related policies and strategies.

At present, the technical content included in regulation has been arranged widely and contains almost all kinds of techniques for energy conservation and renewable resource generation. However, the related economic bodies have no choice but to engage in specific service to achieve the government's stated goals, otherwise, it will be subject to legal or administrative sanctions.

In order to make the implement effectively, regulation must follow these three principles: the provision of energy conservation content should be clear, which will allow the influenced economic bodies understand the concrete demand; for energy conservation on green building, it is important to composite the macro goal into definite technical specifications for industry and implementation; the efficiency supervisory control method should be developed, for example, promoting related laws and strategies on energy consumption standards of green building.

2.2 The Economic Policy System of China's Building Energy Conservation

The economic policy method is based on the theory

of classical economics and welfare economics and used as the governmental intervening method, no matter whether it belongs to punishment or incentives. The economic policy put into to use is to change the marginal cost of benefit subject [17]. In China, the economic policy system includes mainly three parts: economic incentive policy, energy price, and energy conservation label and green building label certification.

In the first part of economic incentive, it contains four main methods: financial subsidy, revenue from tax, lending money to the enterprise and reward. All of those make a few contribution to the five subjects: consumer, which includes the terminal consumer both of individual and company who are all concentrated on the downstream of green building construction; capital construction organization, such as the first class developer who is responsible for preparation of land; development organization, such as the second class developer, owner, estate investor; equipment producer; government.

While in the use of financial subsidy and tax revenue, most of the policy is offered for the development organization, consumers obtain less who would receive more compensation in the second part of economic incentive of energy price policy, especially in the area of renovation of heat metering in north China. However, the conflict between the different economic subjects and the unclear setting of energy price ratio makes it urgent to establish a more marketable and efficiency resource allocation.

So in this condition, in order to meet the demand of energy conservation of buildings in the new economy environment, the government in China has developed energy label certification institution to measure the energy usage efficiency of building and offer energy efficiency information for the market, which now not only contains the energy conservation label certification but green building evaluation standard. What's more, another important complement in the guiding policy is the Voluntary Emission Reduction Plan.

2.3 The Comment of China's Energy Conservation Policy from the Aspect of Economic Efficiency

According to the above analysis, the current China's building energy conservation policies is summarized as following Fig. 1, and a further analysis from the aspect of economic efficiency will be made in the next.

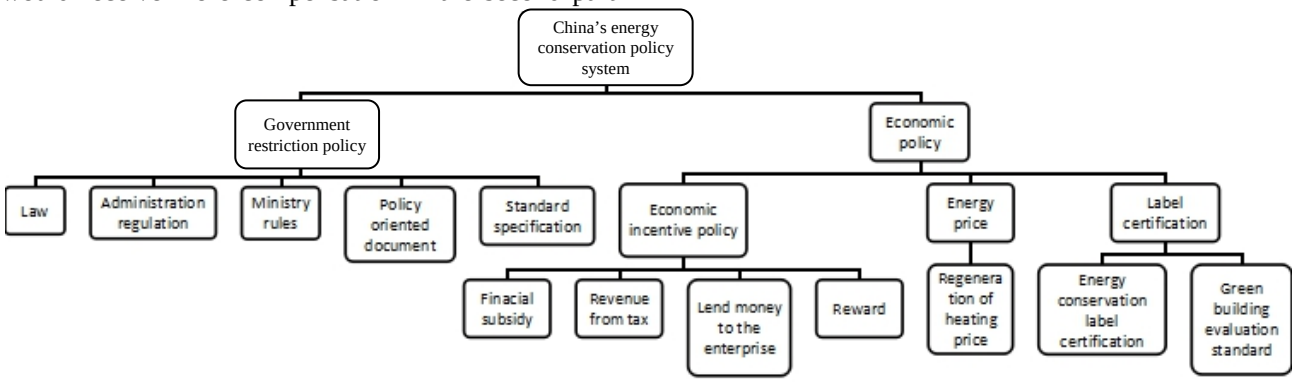

Fig. 1 The framework of current China's building energy conservation policy system.

2.3.1 The Government Restriction Policy

Theoretically speaking, "order and control" method (government restriction policy) can control carbon dioxide emission of building by a clear and specific standard. While in reality, the standards and related regulations of energy saving may not be assessed by social and economic efficiency, so a suitable emission reduction level of building for the overall social benefit is difficult to be determined. Meanwhile, different developers have different production costs

and in the same market there is also concentrating different producing bodies with different marginal costs of energy saving, so "order and control" method which asks for the same level of energy saving measures is not the preferred plan for the whole social economy efficiency.

2.3.2 The Economy Incentives Policy

All the economy incentives in China are equal to a subsidy which transfers the public resource to private part in order to reduce the social influence of externalities. The beneficial parties will give up their originally owned economic property which in fact is the pollution right for producer in the current market mechanism, and in the area of green building construction which is the right of carbon dioxide emission of buildings. Whether the usage of social resource under economy incentives is optimized, it depends on cost of payment by the government (the cost of economy incentives). If the government wants to make use of the economy methods to encourage the property reallocation to reach the destination of mitigation of carbon emission of building, it should take the cost and benefit of the implement of policy and regulation into consideration, due to the reason that policy and regulation depends on the operation and allocation of public resources, while the public resource especially the finance resource is sparse.

3. The Analysis of Cost-benefit Method of Green Building

3.1 The Concept of Cost-Benefit Method of Green Building

Benefit means the increase of human welfare and cost means the decrease of human welfare. So focusing on a policy of green building, it means that the social benefit should be higher than the social cost. There are three basic concepts to further explain the cost-benefit method of green building:

(1) The impact of environmental damage and pollution caused by the construction of ordinary buildings can be assessed by economic loss and be calculated by economic price;

(2) In order to avoid the environmental damage and pollution, society will take measures on green building construction which will increase more incremental cost both in the technological application, trading cost, policy cost and all kinds of cost of capital and asset investment;

(3) The main theory of cost-benefit method is to solve the problem of externality, which is to try to measure the performance of all the costs and benefits by economic price. From the point of view of economy, the value of the cost-benefit method shows the preference of economic subjects, and also shows their willingness to pay.

3.2 The Theoretical Basis of Using Cost-Benefit Method for Analysis on Economic Efficiency of Green Building Policy

Cost-benefit method is widely used in theoretical and practical analysis for climate change and environmental problems and the theoretical basis can be concluded as following five points.

(1) The basic principle of cost-benefit method guides the allocation of resources by measuring the economic benefit, which has wide applicability for policy on current environment with scarce resources;

(2) The process of cost-benefit method requires all participants outline their cost factor and benefit outcome, which can be formed as a list for policy reference;

(3) Cost-benefit method combines the environmental impact with economic and financial effect as a unified way (economic price) to make comparison on every direct and indirect factor;

(4) Cost-benefit method can give the policy maker a reference on what affects that different subjects impact on the environment and can be easily used in the comparison of policy option on different policy objectives;

(5) Cost-benefit method brings in the concept of time using the rate of discount to avoid the effect of different cost and benefit level from different time.

As it mentioned before, in order to solve the problem of policy efficiency, it is essential to develop a framework to make an analysis on the cost and benefit brought by the policy. What makes it important is that it should make the general concept of property theory as its basement and follow the principle of micro economic analysis combining the particularities of problems to establish a full set of operational, suitable and effective principles of property right allocation. In doing so, it will create a set of more concrete means to implement macro goals, applying the cost-benefit analysis of micro economics to the policy system analysis of the green building construction and finally offer a more objective policy assessment tool for government.

3.3 The Basic Model of Cost-Benefit Method of Green Building

3.3.1 Economic Model

Based on the cost-benefit analysis, this part will build a basic calculation model for green building following the three principles: marginal cost and benefit, Present Value and Net Present Value, and decision rules.

(1) Marginal cost and benefit

Under the requirement of economic optimization, it needs to make the marginal cost equal to the marginal benefit, which can lead to an optimized equilibrium point of carbon emission of green building. While in reality government cannot find this point easily due to the policy cost and related particularity of using this method which will be explained in the following part.

(2) Present Value and Net Present Value

In order to solve the problems that how to calculate different green building construction means on the same level and the same green building construction mean in their different points of whole lifecycle, this part will use Present Value (PV) and Net Present Value (NPV) to calculate different periods of cost-benefit of green building.

The basic Present Value calculation equation is

$$PV_C = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} \quad (1)$$

$$PV_B = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} \quad (2)$$

Where PV_c = Present Value of total cost of green building, PVB = Present Value of total benefit of green building, C_t = the cost for the number t years, B_t = the benefit for number t years, r = discount rate, and t = time (year).

The basic net present value calculation equation is

$$\mathbf{NPV} = \sum_{t}^{n} (\boldsymbol{B_{jt} - C_{jt} + B_{et} - C_{et}}) \, (\mathbf{1} + \boldsymbol{r})^{-t} \quad (3)$$

Where NPV = Net Present Value of low-carbon green building, B_{jt} = basic building benefit for the number t years, C_{jt} = basic building cost for the number t years, Bet = basic green building benefit for the number t years, C_{et} = basic green building cost for the number t years, r = discount rate, and t = time (year).

(3) Decision rules

There are three decision rules for evaluating cost and benefit of green building:

i) Present value of total benefit should be higher than present value of total cost and also equal to the Net Present Value should be higher than zero：

$$PV_B > PV_C \quad (4)$$

$$NPV > 0 \quad (5)$$

$$NPV = PV_B - PV_C \quad (6)$$

ii) Benefit-cost ratio should be higher than 1, which means that the increase of Benefit Present Value should be quicker than the increase of Cost Present Value:

$$PV_B/PV_C>1 \quad (7)$$

iii) Internal Rate of Return (IRR) can be used to make an analysis on economic returns of different economic bodies and to make an assessment on an overall cost-benefit returns influenced of different economic bodies on a policy. Calculate net present value of all kinds of cost and benefit and compare IRR

of different policies or projects under the condition of NPV=0, and then choose the policy or project with higher IRR. The equation is:

$$B_0 - C_0 + \frac{B_1 - C_1}{(1+r)} + \frac{B_2 - C_2}{(1+r)^2} + \cdots + \frac{B_t - C_t}{(1+r)^t} = 0 \quad (8)$$

Where B_t = the benefit of carbon reduction in number t years, Ct = the cost of carbon reduction in number t years, t = time (year), i = Internal Rate of Return (IRR) of low-carbon green building policy.

3.3.2 The Cost and Benefit Factors of Green Building Policy Construction

Under the green building construction policy, the economic bodies should undertake extra cost for carbon reduction caused by non-statutory requirements such as incentives, promotion, education, on the basis of statutory regulatory requirements. Meanwhile, all kinds of bodies can obtain corresponding policy benefit. The concrete cost and benefit that each group (the government, which stands for the overall society; organization, developer and investor including the first and second class developer; consumer and user) are facing under extra cost and corresponding benefit are listed on the Table 1.

Table 1 Cost and benefit factors for each economic body.

	Cost	Benefit
Government	Promotion cost of green building construction	Investment reduction of conventional energy resources
	Management cost of policy implementation	Incremental GDP caused by construction of green buildings
	Financial inventive cost	Incremental job opportunities by construction of green buildings
	Subsidy of new energy of industry	
Organization / Developer/ Investor	Low-carbon technologies and facilities	Government financial incentives by adopting low-carbon development model
	Green building design, certification and examination	Rise in selling price and renting price
		Company brand value
Consumer/ User	Maintenance and operation management of new energy facilities	Reduction of energy usage
	Extra cost of buying low-carbon green building	Government financial incentives
	Government financial method (the price of heat supply and power supply)	

3.3.3 The Particularity of Cost-Benefit Method of Green Building

When making a cost-benefit analysis, regulation producer should offer a minimum baseline protection as a rigidity index to guarantee the carbon emission of buildings that is under a safety level to prevent all kinds of groups from irreversibility and maintain basic survival and social interest level. In the analysis of cost-benefit of green building construction, it is necessary to bring in the rigidity index and define the relevant rigid emission index as a constant, and then calculate the highest economic cost of this indicator. In recent international researches, all kinds of Integrated Assessment Model (IAM) are used in cost calculation of carbon emission, by which a pathway of changes of optimized carbon emission can be simulated in marginal cost and benefit analysis. These can help policy makers know about the highest level of carbon reduction cost when a policy implement is according to a quantitative carbon reduction index and promote optimization of social resource allocation.

4. Conclusion

The current system environment in China is transforming from the planned economy system to the market economy system, and the function of the market economy is increasingly perfect in the allocation of social resources. The economic methods to promote public policy, especially in the face of “public goods” problem of the building energy conservation will be an

important direction. The future development of the policy system should follow the dynamic market mechanism and optimize policy system, which must be established on the overall cost-benefit economic efficiency framework. It is necessary to take trading cost of governmental regulation into consideration scientifically and promote the economic incentives to consumer terminal, leading the terminal market demand driven supply.

Meanwhile, it is essential to design a set of operational analysis tools in the project level, and should put the benefits of low-carbon green building construction in a macro economy level from different aspects of economic bodies. More or less, there is an urgent need to establish unified marginal cost (carbon reduction benefit) data guidelines and methods for green building construction policy in China to make the cost-benefit method as the basic policy evaluation method, promote the assessment work of policy means, and develop a basis of estimating social cost of building carbon emissions for the local government. What's more, green building with incremental costs will bring additional incremental investment, which will lead to an additional increase in industrial output during the economic system, and thus will have a macro impact on the overall economy in turn.

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