Research on the investment timing of commercial green property

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ABSTRACT

Green building is inevitable tendency in development. However, most of the developers in China are still waiting for the best timing. Compared with the ordinary ones, green buildings have features of more investment, higher risks, and more repayments. It is suitable for commercial property with consideration of life-cycle cost. How to choose the best timing of investment for commercial green buildings is important and urgent. This paper establishes a decision-making model with the real option theory for green buildings investment opportunity in commercial property and provides some advices to developers creatively, and tests the model by using a numerical simulation with an actual development project's data. It gives method for developer decision-making and advices to government for green building promotion.

KEYWORDS

Green building; Commercial property development; Investment timing.
INTRODUCTION

China is in the accelerated process of urbanization and industrialization. There are tremendous opportunities for the real estate development in urban expansion. However, the building energy consumption accounts for almost 32% of the whole social energy consumption[1]. In December 2009, the United Nations Climate Change Conference (COP15) was held in Copenhagen, Denmark. The general assembly agreed that energy-saving and emission-reduction required the concerted effort of the whole world. It was declared that by 2020, the CO₂ emission of GDP would drop 40%–45% of 2005 in China. In the same year, a report by United Nations Environment Programme (UNEP) announced that 1/3 of the global energy use and the related greenhouse gas emissions were associated with the construction energy consumption. Therefore, green house and energy-saving building will be the tendency in property development. It is helpful for the changeover of city construction modes, decrease of energy consumption and the sustainable development of building industry.

There are perfect practice and evaluation systems, such as BREEM and LEED etc, for green building. And there are a lot of outstanding green buildings in the world, but it is still in the preliminary stage in China. Approximately 99% of the existing building area (almost 40 billion square meters) and 97% of new-building areas are high energy consumption. The heating energy consumption are more than three times of those in developed countries[2].

The "Evaluation Standard for Green Building" and the financial support policy have been issued for the promotion of green building in China. Commercial property has become hotspots of investment because of the macro-control in real estate. The commercial real estate developers pay more attention to the operation cost for the energy consumption, such as service apartment, shopping mall and office building. That’s why it is more significant for green building in commercial real estate development.

Some foreign developers, such as Shui On Land Limited, have begun to research energy saving in commercial property. Because of some factors such as the great uncertainty and heavy cost in early stage of development etc., developers are very cautious in green building investment in spite of its great commercial and social value. So we study the best investment timing of commercial green property by the real option method in order to provide a decision-making model for developers.

Dixit et al firstly framed the analysis of corporate investment issues by the real option method[3]. It is very appropriate to study corporate investment issues by using the real option method for the huge randomness of real estate market. The application research of this theory in real estate investment by using the real option method was initiated by Titman[4]. He regarded option to defer as a non-dividend American call options. Then, the real option method become more achievement in research and is applied widely to the related problems in real estate[5]. (Yavas, et al.) Sing and K. Patel found that the investors had better wait for clearer message at the appearance of high market uncertainty by the empirical study on England real estate market[6]. The similar research in China includes: Cai et al. studied the decision-making of real estate investment based on the condition of randomness of price[7]. Ke et al. structured the multi-stage decision-making model according to the policies and features of real estate market[8]. Given the uncertainty of demands and costs, Luo et al. studied the optimal timing and the best development intensity for developers[9].

Based on the above studies, we discuss the best opportunity for green buildings development compared the costs and returns between the normal buildings and green buildings for commercial property. The innovation of this paper is providing reference to developers by the research in the circumstance of energy saving, and structuring the model with consideration of the accidents on random points based on the uncertainty of energy prices represented by Brownian motion in commercial property development.

MODEL DESCRIPTION

The construction cost of green buildings includes building cost and operation cost (green buildings in this paper are all refers to commercial green buildings without specification for convenience). Extra costs are needed during construction for Green Building Standards, such as purchase of water-conservation equipments and air quality testing facilities. But the operation cost, especially the energy consumption, is lower. Otherwise, the green building developers gain first-mover advantages in public praise, corporate image, leading technology, and raise comprehensive benefits. Green buildings have the commercial value such as cost reduction, building value improvement, financial subsidies and corporate image with quality.

The assumption is the developer prepare to develop a commercial property for rent in this paper. It could be a normal building or a green building. So when is the best timing for green building is the most important deciding-making problem for the developer. In the model, green building project is an investment with initial incremental cost and subsequent continuous profit flow in abstract. The profit flow is the operating cost savings. The decision is developer needs input incremental sunk cost for financial subsidies and corporate image improvement.

There are some basic simplifying assumptions to make the decision model feasible.

1. Risk-neutral Hypothesis. We assume the investor is risk-neutral in real option analysis because of the distorted option value by risk preference in decision-making process.
2. Development intensity is established. We study whether developers choose green building without involvement of development intensity in the paper.
3. Random process hypothesis. The real estate is supposed to display geometric Brownian motion and Poisson jump process in order to describe its uncertainty.
4. Construction cost hypothesis. Compared with the normal building, the incremental cost per unit building area is I, and I is not the whole costs of development.
5. Risk-free interest rate hypothesis. The risk-free rate is assumed to be.
6. Green building commercial value hypothesis. The commercial value of green building includes operation cost reduction, building value improvement, corporate image improvements, and subsidies, etc. $\theta$ represents the operation cost reduction of green building, namely the profit flow. The invisible corporate value improved for unit area value is monetized by $A$ and $B$. $\theta$ represents the government fiscal subsidies. Firstly, we assume that $\theta$ follows a geometric brownian motion for it can characterize the uncertainties in energy price increase. Moreover, $\theta$ also has upward Poisson jumps at some random points, such as the fluctuation of energy price by war or emergency, some encouragement or punishment policies. Based on the two uncertainties above, we assume that $\theta$ obeys Brownian motion jump process.

$$
\frac{d\theta(t)}{\theta(t)} = \alpha \, dt + \sigma \, dW + \theta \, dq
$$

(1)

In formula (1), $\alpha > 0$ and $\sigma \geq 0$. $\alpha$ represents the expected drift rate, and $\sigma$ represents the volatility. Formula (1) shows that $\theta$ fluctuates as geometric Brownian motion, it rises in a small probability $\lambda \, dt$ intervals of $dt$ and continues fluctuating until another event. $dq$ represents the increment of Poisson process with an average arrival rate of $\omega \lambda$. When the random increment occurs, $q$ will rise the fixed percentage $\phi$ in the probability of $1$, $dq$ obeys formula (2):

$$
\frac{d\theta(t)}{\theta(t)} = \begin{cases} \phi(t) > 0, & \text{Probability } y \lambda \, dt \\ 0, & \text{Probability } y 1 - \lambda \, dt \end{cases}
$$

(2)

In formula (2), $\lambda$ and $\phi$ represent the intensity parameters of Poisson process. $\phi \geq 0$, $\lambda \geq 0$. We choose the optimal investment strategy by dynamic programming. Neutral-risk is assumed for the corporation so that the discount rate is risk-free. The Bellman equation of investment opportunity values

$$
F(\theta) = rF dt = E(dF)
$$

(3)

Expanding formula (3) by using the Ito Lemma mixed the Brownian Motion and Poisson process, we will get:

$$
\frac{1}{2} \sigma^2 \theta^2 F_{\theta \theta} + \alpha \theta F_{\theta} - rF(\theta) + \lambda F(\theta) - \lambda F[(1 + \phi) \theta] = 0
$$

(4)

Assuming the solution of formula (4) is $F(\theta) = L \theta^{\beta_1}$, and it is substituted into formula (4). $\beta_1$ is the normal solution for the nonlinear equation.

$$
\frac{1}{2} \sigma^2 \beta(\beta - 1) + \alpha \beta - (\gamma + \lambda) + \lambda (1 + \phi)^{\beta} = 0
$$

(5)

Simultaneously, $F(\theta)$ obeys three boundary conditions:

$$
F(0, t) = 0
$$

(6)

$$
F(\theta^*, t) = \theta^* - (1 - A - B)
$$

(7)

$$
F_{\theta}(\theta^*, t) = 1
$$

(8)

$\beta_1$ in formula (5) has no analytical solution, but we can find a $\beta_1$ in the number which can satisfy formula (5) and formula (6). When $\beta_1$ is given, we can find the investment threshold $\theta^*$ and $L$ according to the boundary conditions 8 and 9.

From $L \theta^{\beta} = \theta - (1 - A - B)$ and $L \beta \theta^{(\beta - 1)} = 1$, the solution is:

$$
\theta^* = \frac{\beta_1}{(\beta_1 - 1)(1 - A - B)}
$$

(9)

$$
L = \left(\frac{\beta_1 - 1}{1 - A - B}\right)^{\beta - 1} \left(\frac{1}{\beta_1}\right)^{\beta}
$$

(10)

$\theta^*$ represents the business investment threshold. When $\theta(t) \geq \theta^*$, developer can choose green building. When $\theta(t) < \theta^*$, it should to wait.
NUMERICAL SIMULATION

The data involve in the model can be measured, so the model is strongly practicable.

**TABLE 1 : The main parameters in the model**

<table>
<thead>
<tr>
<th>The input parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>the drift rate(%)</td>
<td>4</td>
</tr>
<tr>
<td>The incremental costs(yuan/m²)</td>
<td>367</td>
</tr>
<tr>
<td>Risk-free interest rate(%)</td>
<td>7.05</td>
</tr>
<tr>
<td>Poisson jump intensity</td>
<td>0.05</td>
</tr>
<tr>
<td>Government subsidies</td>
<td>80</td>
</tr>
<tr>
<td>Corporate image value</td>
<td>50</td>
</tr>
</tbody>
</table>

For simplicity, the actual incremental profit flow of project is replaced by the power fare saving in this paper, and it doesn’t affect the calculation. According to the incremental cost statistics of 77 typical green building projects issued by the Ministry of Housing in November 2010, we find that the incremental cost of the three-star green building is 367 yuan per square meter. The risk-free rate is 7.05% according to the five-year lending rate issued by People's Bank of China in 2012. The green buildings above two-star can be rewarded. The award criteria in 2012 is: 45 yuan/m² for two-star green buildings and 80 yuan/m² for three-star. The criteria will be adjusted along with the technical progress and cost variation. The parameters of the example is shown in TABLE 1. When $\sigma = 0.05$, $\varphi = 0.05$, we can get the results:

$$\beta_i = 1.6273, \theta = \frac{\beta_i}{(\varphi_i - 1)} = 614.8256$$

The profit flow of this investment includes the operating cost reduction and the rent increase in comparison with normal buildings. $\theta$ indicates the total operating cost savings per unit building area of the green building. It is much more than the initial incremental cost of 367 yuan. $\varphi$ refers to the volatility of the operating cost savings. $\sigma$ refers to the intensity of the jump. These two represent the relationship between the uncertainty parameter and the coefficient of investment thresholds.

Figure 1 shows the value of the investment threshold $\theta^*$ when $\varphi = 0, 0.05$ and $0.1$. We find the greater the volatility $\sigma$ and $\theta^*$, the greater the uncertainty, risks and profits. So the developer would wait for more profit. The larger the $\varphi$, the higher the investment threshold.

The three curves in Figure 1 are the graph of $\sigma$ when $\varphi = 0.1$, $\varphi = 0.05$ and $\varphi = 0$. When the other coefficients are equal, the bigger $\theta$ and $\theta^*$, the higher the option value of investment opportunities. Meanwhile, the lower the waiting cost. So we can draw the conclusion 1.

Conclusion 1: From the critical value of investment, both the uncertainty of Brownian motion and the intensity of Poisson jump can strengthen the willingness to wait. In other words, the developer had better postpone the investment decision when uncertainty.

![Figure 1 : Critical value of investment is function of uncertainty $\sigma$](image)

**EMPIRICAL TEST**

Due to the simple structure and use rationality of the LEED system, the green building energy-efficient standards refer to it in this paper. The green buildings save 10% in energy compared with the normal buildings in LEED, which is used as the data basis.
In this paper, we take the commercial development project ‘QYTD’ in Chongqing as example. Assuming the service life of the commercial building is 40 years, and it is used for 360 days per year. The T1 building is a 31-storey office building of 41554m². Through the simulation, we find its annual electricity consumption is 7743900 kWh, and the average annual power consumption is 186.3575 kWh/m². For LEED standards, the electricity savings of the green building is 26.09005 kWh/m², and the overall saving is 1084145.9377 kWh per year for 41554m². It can’t be ignored for the rising energy price.

Calculating by the optimal investment threshold $\theta^* = 952.0717$, 40 years of service life, 7.05% of discount rate, 26.090 kWh/m² of electricity savings, the investment threshold is 1.778 yuan/kWh. The conditions for choosing green building is the electricity price raised to 1.778 yuan/kWh without consideration on the intangible values, such as corporation image, the first mover advantage and the environmental values, etc.

T1 uses the power distribution system of 10kv/0.4kv with price of 0.828 yuan (data sources: the power company official website). The current electricity price doesn't reach the threshold, but the developer still design and construct green building. This contradictory result is inherently rational for strong environmental awareness and investment prospective for foreign developer, who pays more attention to the comprehensive effect and the corporate image. That is improving the figure of the corporation image value $A$in the model. Changing the value of corporation image $A$ and the subsidies $B$, we can get the investment critical electricity price in TABLE 2 and draw the conclusion 2.

Conclusion 2: when the values of subsidies $B$ and corporation image $A$ are increased with other constant parameters, the willingness of green building development will be strengthened, the investment threshold and the waiting time will be significantly lowered. That is, when the government subsidizes or image value of green building is higher, partial incremental costs can be offset. It is easier for developer to make decision.

<table>
<thead>
<tr>
<th>Corporate image value A (yuan/m²)</th>
<th>Government subsidies B (yuan/m²)</th>
<th>Critical price (yuan/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>80</td>
<td>1.778</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
<td>1.403</td>
</tr>
<tr>
<td>50</td>
<td>100</td>
<td>1.628</td>
</tr>
<tr>
<td>160</td>
<td>100</td>
<td>0.803</td>
</tr>
</tbody>
</table>

**CONCLUSION**

This paper uses the real options method to study on the optimal timing of commercial green building development, by numerical analysis models. The result indicates that the higher the volatility of the uncertainties, the higher the option value and the trigger. It is helpful for developer to choose the optimal timing and flexible decision-making method by quantifying the complex uncertainties in the economic environment.

Meanwhile, it can advise the government to promote the green building development effectively in policy-making by analyzing investment behavior. The policy suggestions are: The government should keep the stability of energy prices for green buildings promotion, increase public awareness on green building by publicity of energy-saving and low-carbon lifestyle, and encourage green buildings by subsidies as well as compulsory measures.

**REFERENCES**