OPEN ACCESS

1st World Sustainability Forum
1-30 November 2011

www. wsforum.org

Article, Review, Communication (Type of Paper)

Modeling the decision-making of real estate developers in the Building Energy Efficiency (BEE) market- A game theoretic model from transaction costs perspective

Queena K. QIAN[1,3,*] and Edwin H.W. Chan[2]

[1]PhD student, Building and Real Estate Department, The Hong Kong Polytechnic University, Hong Kong S.A.R., China

[2] Professor, Building and Real Estate Department, The Hong Kong Polytechnic University, Hong Kong S.A.R., China

[3]Guest Researcher, Wuppertal Institute for Climate, Environment and Energy, Germany

E-Mails: [1]kun.qian@fulbrightmail.org; [2] Edwin.Chan@inet.polyu.edu.hk; [3] kun.qian@wupperinst.org

* Queena K.QIAN, Tel.: +49 157 345 29553

Mail Address: Research Group 2, Wuppertal Institute for Climate, Environment and Energy, Döppersberg 19, 42103 Wuppertal, GERMANY

Received: / Accepted: / Published:

Abstract

Modeling Building Energy Efficiency (BEE) market with game theory can provide insights on the interactions amongst the different stakeholders, possible choices and likely outcomes available to them in different scenarios. Competition between the developers is an important aspect determining the supply of BEE in the market. This implies that if the demand and price of BEE are exogenous, then the developers have no options but to compete with each other and reduce the cost of BEE in order to maximize their profits. Moreover, there are many factors both rational and irrational, such as information asymmetry, opportunistic behavior, ill-informed users, lacking mandatory requirements, etc., which incur different levels of transaction costs. This may affect the willingness of the developers to take part in BEE market. Therefore, this study is to look into the developer's decision-making on BEE in two different scenarios: 1. without considering transaction costs; 2. with transaction costs into consideration. By modeling the game between developers over BEE investment, we will investigate the mechanism of competition between developers, look into the transaction costs impacts on game equilibrium. The findings will support some of the transaction cost theoretical statements under the BEE real estate development scenario using the game model, and effectively explain what the mind-set of the developers is and how their decision-making of BEE is reached. The findings will also help draw policy implication on how to increase the willingness to supply from the developers by reducing the market transaction costs.

Keywords: Building Energy Efficiency (BEE); game model; transaction costs; real estate developers

Introduction

Energy consumption in the construction industry takes up around one third of the total energy consumption in most economies and in Hong Kong, buildings consume 81% of the electricity power. Improving the efficiency of energy use in the construction industry has become a well-recognized approach for the government to meet national and international objectives to mitigate climate change, decrease global warming and improve the situation of air pollution (Meyers, 1998).

Current BEE researches are mainly focused on pure technology improvement from engineering point of view, or policy study for the operation of government. However, there is a lack of concern and neglect of study on the role of transaction costs that affect the economic effectiveness of policy implementation and market reaction. With the current sophistication of technology, a better designed policy package to promote BEE, will lift the effectiveness and efficiency by 40% (OECD, 2003). Thus, there is a great potential to study the stakeholders' concerns and transaction costs impact that affect the BEE investment.

Real estate developers, who initiate building projects, are the dominant force in building market and thus form the study objects of this research. As most incentive schemes are voluntary basis and market-based, the stakeholders involved are free to adaptor avoid it. There are two major reasons that real estate developers are not attracted by or interested in most of the existing incentive schemes. First, the benefit from the schemes is not enough, which means that the incentive itself is not beneficial to the potential market parties and they do not care. Second, the extra transaction costs involved is too much and the developers would rather give up the potential benefits to avoid the troublesome attached. Therefore, it is rational to build up a game theory model between developers to see how their decision-makings are made on BEE with transaction costs being considered, and how could the incentives be better designed with the understanding from the decision-making process.

Game theory deals with how individuals behave in interdependent decision situations. With regarding to the BEE market, if a developer decides to develop BEE, the consequence of this decision for its welfare not only depend on this move but also on decisions made by other stakeholders, such as the choices of other developers, preferences from the end-users and policy interventions from the governments, etc. The same theory holds for other stakeholders. Moreover, it is important to forecast reactions from market participants in light of certain policy implementation, based on the simulation of decision-makings among the stakeholders.

Comparing to classic economics of a market with perfect competition, game theory has been rendered mathematically and logically to analyze the interactions between stakeholders, from a micro analyses perspective. It helps us to better understand the underlying mechanism and essence of market and thus provide a sound rationale for policymakers. However, the research gap remains as follows:

Firstly, Competitions between the market stakeholders, i.e., developers, have a direct impact on the market supply of BEE. And transaction cost factors, such as information asymmetry about BEE cost and performance, demand forecast, development strategy of the counterpart, would hugely affect each developer's decisions upon BEE development. Therefore, the authors are motivated to model the BEE market from the developers' perspective, taking account of the transaction costs involved.

Secondly, few game models applied to BEE market have been done with a systematic approach. They are mostly done with a payoff matrix of indicative outcomes, which prevent further investigation on equilibrium implications, for example, with or without transaction costs considered. There is a lack of a comprehensive and in-depth study of the particular impacts of transaction costs on the BEE market and how it helps on policy improvement, given different institution contexts.

Aim and objectives

The aim of the research is to study the developers of their investment concerns to BEE by game modeling the interactions between two developers upon their decision-making, by taking the transaction costs into the consideration. It is to explain theoretically that transaction costs is not neglectable in BEE studies, and it is a leverage point to both make the market welcome BEE and the government policies favorable and effective, by taking transaction costs concerns serious.

Hence, the objectives of this study are (i) to build up the games between developers on their BEE decision-makings without the existence of transaction costs, and (ii) to explore and compare how the game develops when taking transaction costs into the consideration of the decision-making process between the developers

This study will initially benefit the real estate developers who would like to be better informed of the extra costs involved with BEE investment. With the identified concerns of developers in investing in BEE, it also helps government's policy making, especially in designing suitable incentive schemes.

Literature review

1. The context of game between the developers

Discussions on barriers to BEE development include market failure, information asymmetry, consumer behavior, higher initial cost and risks in market, etc (WBCSD, 2009; Qian and Chan, 2011, Qian, 2011). Substantial literature suggests, however, that an inadequate supply of BEE is an important factor that prohibits the BEE market from scaling up. It follows the logic that due to the higher costs of BEE and potential risks involved in the real estate development process, the developers are reluctant to take initiative in BEE investment, given the relatively less competitive advantage in price over its conventional counterparts. From the developers' point of view, in most cases, investing in BEE is less appealing than its conventional counterpart, in view of the higher initial development costs, less competitive price, dubious energy efficiency performance and other unpredictable risks.

Since the demand for BEE products in the real estate market is relatively limited, when the developer decides to invest in BEE, it has to compete with each other to divvy up the BEE market. It is important to analyze the nature of competition in BEE market before looking into the barriers faced by developers. If the BEE market is perfectly competitive with complete information, which means: (1) There is no transaction cost at all. (2) Each developer treats its counterpart as passive features of the environment. (3) There are no entry and exit costs in the BEE market. (4) All the developers provide homogeneous products. In this case, the supply of BEE will increase until competition drives all profits to zero, with market price of BEE equal to average marginal development cost. However, given the supply side constrains such as fixity in land, density control through zoning, and the typically heterogeneous products by location and type, BEE market in the real world is commonly regarded as an imperfect competition market and an oligopoly. The reasons are as follows: firstly, real estate is often associated with the scarcity of land and natural monopolies, once the developer decides to develop a conventional building, there are no other alternatives for consumers to choose given the same location. Secondly, since the demand for BEE is affected by price, levels of income, consumer awareness and preference, etc., and energy is typically a small portion of total occupancy costs for buildings, benefits from energy efficiency improvements are usually trivial and ignored by both developer and end-user. Lastly, transaction costs, such as incomplete and asymmetric information about BEE demand, cost information, technology and product, are pervasive among developers, which as well constitute a fundamental characteristic of the real estate industry.

2. Transaction costs in the game between the developers

Apart from higher extra construction cost needed for BEE development, barriers due to transaction costs factors in the whole development process, such as asymmetrical and incomplete information, risk aversion, regulation distortion and unfair competition, etc., are the main causes prohibiting the developers from engaging in BEE market.

The argument is well known in new institutional economics, especially for developing countries, where the transaction costs are much higher to motivate an efficient BEE market, due to factors such as the immature market-oriented economy, lack of access to BEE information, technology, corruption in governments and insufficient professionals. Take China as an example, along with the rapid growing economy, fast urbanization, rising income levels, improvements in environment awareness and increase in energy prices, it is expected that BEE market would expand as world's biggest real estate market and soaring construction industry. Nevertheless, the compliance of building codes is still relatively low in major cities, and much lower in peripheral provinces, small cities and vast countryside (Qian and Chan, 2010; Chan et al 2009). Total quantity of green buildings is only around 20 million square meters, less than 0.05% of the whole building stock. Therefore, it raises the argument that transaction costs, rather than extra physical costs for BEE, which is merely 4-5% higher than that of conventional building, might be the overriding reasons prohibiting the BEE market from booming (Qian, 2011).

To further shed light on the impacts from transaction costs, we categorize the costs of BEE development into three parts: The first part is the sum of costs of different inputs to develop conventional buildings, including capital, labor, land and raw materials. The second part is the sum of extra physical costs needed to develop BEE, including expenditures for extra tasks to be done by developers for BEE, such as carrying out extra BEE market survey, planning, design, construction, marketing or leasing, etc. The third part is the sum of costs related to other transactions incurred, which consists of costs for covering various uncertainties in the process for developing BEE, in terms of risk of time, cost and government, selling problem and consequence for property management, etc. Noted that in a generic case, the first part can be interpreted as the production cost for conventional building, the second part as the extra production cost for the special features of BEE, the third part as the transaction costs incurred for developing BEE. Furthermore, in a much broader sense, the second and third parts of costs defined here both can be referred to as transaction costs for developers. The former represents standard extra consideration that could easily be covered by an extra % expenses or fees, while the latter is difficult to gauge but can be interpreted as a function of the quantity of BEE products developed. This study will only focus on the latter part of the costs, compared to its non-BEE counterpart that, in fact, influence the developers' decision-making of BEE investment.

More specifically, the developer in the BEE market always adopts a differentiation strategy to maximize profit, providing the value to end-users through the unique features of the BEE product, such as the location, layout, facilities, traffic conditions and the surroundings, as well as energy efficiency. Extra transaction costs for developing BEE are one of the determinant factors to distinguish the developers from each other in the market. Besides, for a typical building project, different kinds of transaction costs, such as searching and information costs, contracting and enforcement costs, are involved in the development process, no matter whether a conventional building or an energy efficient one. Thus, extra costs needed to develop BEE, compared to conventional building, can only be investigated on a hypothetical basis. Last but not least, the transaction costs difference in the BEE market may also arise from the developer himself, since the perceptions of transaction costs in terms of time, risk and money differ from one to another, in line with the variety of awareness on BEE, scale, market share, position, as well as development strategy of different developers.

To keep things simple and focused on the BEE market, it is always reasonable to assume that, with the diffusion of information and know-how to develop BEE, costs for constructing conventional buildings are identical for different developers, according to the complete information and perfect market hypotheses. Consequently, transaction costs, accrued in the real estate development process of BEE, contribute to the unique competence for the developers in the BEE market. Rather than presenting econometric estimates of the detailed transaction costs in the development process of BEE, the authors will explicitly introduce transaction costs as a whole in a systemic game model to explore the impacts on the stakeholders in the BEE market.

Methods: Modeling the BEE decision-makings between developers

Presenting the game model between the developers

Based on the static Cournot game model (Cournot, 1897), we present the BEE market in a two-developer setting, with both pursuing maximization of profits in developing BEE and competing in a localized market. To maintain our emphases on the core questions, that is, the interactions between the developers and the impacts from transaction costs, we have purposely assume there is no product differentiation of BEE provided by different developers, and take scenarios with/without transaction costs into consideration respectively rather than the whole nature of the real estate sector. This is done so as to capture the most important elements that characterize the barriers in the BEE market in terms of transaction costs, and draw policy implication for promoting BEE development in a more generic context.

Following the analyses of the BEE market above, since it would take a period of time for the process of BEE development, the developers have to make decisions based on their expectations about the BEE market demand independently and simultaneously with each other, competing in quantities of BEE developed to maximize profits. They do not cooperate on BEE development, and each developer's decision affects the price of BEE, thus, it is natural to frame the game model between the developers as the static Cournot game model. We assume the developers are economically rational and act strategically towards each other, and the payoff to each developer depends on the market price of BEE, each developer's own costs and quantity of BEE it developed. This assumption captures some point of real life, and allows us to express the payoff as a function of quantity of BEE developed, just the same as the profit function.

In general terms, let $\mathrm{I} = \{1,2\}$ be the set of players (the developers) involved in the game model for BEE development, let R_i denote the profit of developing BEE for Developer i. The profit function is assumed to be linear in quantities of BEE, and each developer determines the quantity of BEE he wants to develop by solving the following optimization problem:

$$\mathrm{Max}\ R_i = p * q_i - C_i(q_i)$$

$$\mathrm{s.t.} q_i = f_i(x_{1,} x_{2,} \dots \dots x_{n,})$$

where R_i is the profit of developing BEE for Developer i, q_i is the quantity of BEE by Developer i, x_i (i=1,…,n) is the quantities of inputs such as land, labor, capital, construction and raw materials, f_i is the production function for Developer i, $C_i(q_i)$ is the cost per unit to develop BEE for Developer i , and p is the price per unit of BEE in the market, which is commonly assumed as a decreasing function of total supply of BEE product in the market. In a more specific way, $C_i(q_i)$ can be assumed in a linear function form as:

$$C_i(q_i) = \sum_{k=1}^{n} c_k * q_i$$

Where c_k is the cost per unit of input k for developing BEE, which is determined empirically in the BEE market.

Modeling Result and Discussions

1. ***Game model between the developers without transaction costs***

Transaction costs are accepted as the most fundamental feature of the real world in modern economics, as contended by Coase (1937, 1961). Without considering transaction costs, it is unfeasible to understand the proper working of the economic system. As for the BEE market, though, it is interesting to frame a game model without transaction costs firstly, the same as a scenario of perfect market assumption, so as to lay the foundation for further analyses when transaction costs are considered.

We assume two developers compete in a perfect market with zero transaction costs, implying that the information is perfect for each other. Thus the market price of BEE, the quantity and cost of BEE developed by each other are all treated as common knowledge. Normally, the price of BEE is assumed as a decreasing function of total quantity of BEE developed, let $P(Q)$ denote the price function,

$$p = P(Q)$$

$$s.t. Q = q_1 + q_2$$

where Q is total quantity of BEE by Developer 1 and 2. In the Cournot game model, each developer determines the quantity of BEE so as to maximize his profit, which is the revenue minus its cost. Given the decision by the opponent developer, the optimum quantity of BEE to be developed that maximizes profit is found. As described above, the profit for Developer i is:

$$\text{Max } R_i = q_i * P(Q) - C_i(q_i)$$

Hence, take the derivative of R_i with respect to q_i, and set it to zero for maximization:

$$\frac{\partial R_i}{\partial q_i} = P(q_1 + q_2) + q_i * \frac{\partial P(q_1 + q_2)}{\partial q_i} - \frac{\partial C_i(q_i)}{\partial q_i} = 0$$

The values of q_i that satisfy the equation are usually defined as the best responses, let them be q_1^* and q_2^* respectively,

$$q_1^* = f_1(q_2), q_2^* = f_2(q_1)$$

By solving the above equations simultaneously, the Nash equilibriums (q_1^*, q_2^*) are thus where both q_1^* and q_2^* are best responses given those values of q_2^* and q_1^*.

To make the outcome more illustrative for the BEE market and without loss of generality, we consider a simple scenario with a linear price function given by:

$$p = P(Q) = a - (q_1 + q_2)$$

And assume each developer has the same cost to develop per unit of BEE, let c_0 be the cost per unit to develop a conventional building, and c be the extra cost per unit to develop BEE, then the total cost for Develop i is:

$$C_i(q_i) = c_0 * q_i + c * q_i$$

Proposition 1.The unique Nash equilibrium quantities of BEE in the game model between the developers without transaction costs are given by:

$$(q_1^*, q_2^*) = \left\{\frac{1}{3}(a - c - c_0), \frac{1}{3}(a - c - c_0)\right\}$$

And the Nash equilibriums payoffs, that is, the profits of developing BEE are:

$$(R_1^*, R_2^*) = \left\{\frac{1}{9}(a - c - c_0)^2, \frac{1}{9}(a - c - c_0)^2\right\}$$

Proof. To determine the Nash equilibrium, we solve the best response functions above under this scenario, which are:

$$q_1^* = \frac{1}{2}(a - q_2 - c - c_0)$$

$$q_2^* = \frac{1}{2}(a - q_1 - c - c_0)$$

Solving the two equations simultaneously, we have the Nash equilibriums (q_1^*, q_2^*) for Developer 1 and 2:

$$q_1^* = q_2^* = \frac{1}{3}(a - c - c_0)$$

Then the optimum profit for each developer is:

$$R_1^* = R_2^* = \frac{1}{9}(a - c - c_0)^2$$

Moreover, following the discussion about the BEE market as an oligopoly in the previous section, we further compare the results with a BEE market of only one monopoly. Assume that the quantity of BEE developed by the monopoly is Q, by maximizing the profit function:

$$\text{Max } R_i = Q * (a - Q - c - c_0)$$

Let the first-order of R_i with regard to Q be 0, we get the optimum quantity of BEE developed by the monopoly:

$$Q^* = \frac{1}{2}(a - c - c_0)$$

And the optimum profit for the monopoly is:

$$R^* = \frac{1}{4}(a - c - c_0)^2$$

Proposition 2. Quantity of BEE developed in the monopoly market is smaller than that in the perfect market with two developers, but the monopoly profit is bigger than profits of the two developers combined in a competitive market.

Proof. Compare the monopoly case with the results we deduced above, clearly, we have:

$$Q^* = \frac{1}{2}(a - c - c_0) < q_1^* + q_2^* = \frac{2}{3}(a - c - c_0)$$

$$R^* = \frac{1}{4}(a - c - c_0)^2 > R_1^* + R_2^* = \frac{2}{9}(a - c - c_0)^2$$

<u>Findings:</u>

- Under the assumption of perfect information, the cost to develop BEE is equal for all developers and each developer has the same share of the BEE market.
- Supply of BEE in a competitive market is bigger than that in a monopoly market, thus, policies from governments should be prioritized to break up monopolies and encourage competition, for example in the land market, so as to promote BEE development from the supply side.
- By increasing competition in the BEE market, it benefits the end-users from the two aspects: 1. more BEE products available in the market; 2. increased total consumer surpluses in market.

2. Game model between the developers with transaction costs

We improve the game model between the developers by taking the transaction costs into consideration, and then the previous cost function for each developer can be improved as the following form:

$$C_i(q) = c_0 * q_i + \sum_{k=1}^{n} c_k^i * q_i + TC_i$$

Where for Developer i, c_0 is the cost per unit to develop conventional building, c_k^i is the cost per unit of extra input k to develop BEE, and TC_i is the total transaction cost in the development process1. As discussed previously, provided with the inherent aspects of transaction costs in the development process of BEE, we assume TC_i is monotonically increasing and concave function of quantity of BEE developed, that is, $\frac{dTC}{dq} > 0, \frac{ddTC}{ddq} < 0$, implying that when the quantity of BEE developed expands, the total transaction costs increases as well, while the marginal transaction cost per unit to develop BEE decreases accordingly.

For simplicity, we assume that the price function of total quantity of BEE developed is linear, with the following form:

$$p = P(Q) = a - (q_1 + q_2)$$

Where p is the price of BEE in the market, q_1 and q_2 are the quantities of BEE developed by Developer 1 and 2 respectively. To start, we assume both developers have the same physical costs and transaction costs to develop BEE, and the transaction costs are common knowledge to each other, and have the function form as $TC_1 = TC_2 = k\sqrt{q}$ $(k > 0)$, which clearly satisfy our postulate above. Let$\sum_{k=1}^{n} c_k^1 =$ k=1nck2=c, then cost function for developer i is:

$$C_i(q_i) = c_0 * q_i + c * q_i + k * \sqrt{q_i}$$

---

[1] Noted, this game model only focuses on the extra efforts of BEE comparing to the conventional buildings, thus, the physical costs and transaction costs are the extra costs that BEE have, whereas conventional ones have not.

Solving the conditions for profits maximization, the best response functions are:

$$q_1^{**} = \frac{1}{2}(a - q_2 - c - c_0 - \frac{k}{2\sqrt{q_1}})$$

$$q_2^{**} = \frac{1}{2}(a - q_1 - c - c_0 - \frac{k}{2\sqrt{q_2}})$$

Noted here it is difficult to yield the Nash equilibriums from the two equations above directly, since it involves a complex cubic equation that may have imaginary number solutions. Yet we still can have a restricted view of the new Nash equilibriums from the intermediate solutions, which are:

$$q_1^{**} = q_2^{**} = \frac{1}{3}(a - c - c_0) - \frac{k}{12\sqrt{q_1^{**}}} < q_1^{*} = q_2^{*} = \frac{1}{3}(a - c - c_0)$$

We find that with transaction costs being considered, both developers in the game reduce the quantity of BEE they developed, compared to the scenario without transaction costs. The higher the transaction costs are, the smaller quantity of BEE would be developed.

To shed light on the impacts from transaction costs in more detail, we further assume both Developer 1 and 2 have the same physical cost to develop BEE, yet with different transaction costs behind, yielding the new form of cost function for the developer:$TC_i = k_i * q_i$. The linear function form assumption actually captures some points of the BEE market. On the one hand, when BEE accounts for a relatively small share of the whole real estate sector, it is reasonable to assume the total transaction would increase almost linearly until the market matures. On the other hand, due to the high initial investment in the BEE development process, for each BEE project, it is typical for the developer to calculate the development costs on an average basis for each BEE project, a linear or piecewise linear function form assumption for transaction costs makes sense as well. Under this scenario, we have:

Proposition 3.The unique Nash equilibrium quantities of BEE in the game model between the developers with transaction costs are given by:

$$(q_1^{***}, q_2^{***}) = \left\{\frac{1}{3}(a - c - c_0 - k_1) - \frac{1}{3}(k_1 - k_2), \frac{1}{3}(a - c - c_0 - k_2) - \frac{1}{3}(k_2 - k_1))\right\}$$

Proof. We can deduce the results with the similar method in Proposition 1.

Besides, clearly in the equilibriums of the BEE market, we have:

$$q_1^{***} = q_2^{***} = \tfrac{1}{3}(a - c - c_0 - k_i), \text{ if } k_1 = k_2.$$

$$q_1^{***} > q_2^{***}, \text{ if } k_1 < k_2.$$

$$q_1^{***} < q_2^{***}, \text{ if } k_1 > k_2.$$

Compare the equilibrium with that in the scenario without transaction costs, yielding that:

$$q_1^{***} + q_2^{***} \leq q_1^* + q_2^*$$

$$q_1^{***} > q_1^*, \text{ if } k_1 < \frac{1}{2}k_2.$$

$$q_1^{***} \leq q_1^*, \text{ if } k_1 \geq \frac{1}{2}k_2.$$

$$q_2^{***} > q_2^*, \text{ if } k_2 < \frac{1}{2}k_1.$$

$$q_2^{***} \leq q_2^*, \text{ if } k_2 \geq \frac{1}{2}k_1.$$

Findings:

- For each developer, the quantity of BEE developed in the scenario with transaction costs is smaller than that in the scenario without transaction costs. The higher the transaction costs, the smaller the quantity of BEE it would develop.
- In the equilibriums, the developer with lower transaction costs has a higher market share, testifying that it is crucial for developers to increase market competitiveness through reducing transaction costs in its process of BEE development.
- The model also justifies that the government interventions, by all means of reducing transaction costs in the BEE market, which would benefit not only the end-users but also the developers. From the perspective of TCE, the policy package may include government subsidies and grants, incentive schemes, to improve awareness among the developers.

Conclusions

In this paper, three propositions regarding to the game modeling between developers are proposed, with/without considerations of transaction costs. They all serve the different purposes to explain or imply the transaction costs impacts to the decision-making of BEE among the developers. Test results of the propositions and impactions are summarized in Table 1.

Table 1. Concluding summary for the proposition and findings

Propositions	Contribution	Implications to the market and policy-makers
P1 P2	Given to the assumption of the perfect market, the profits of developing BEE would be equally shared among the developers, and they would get the same share of the BEE market. Competition contributes to the growth of the BEE market supply, given the assumption of perfect information.	The government will want to make sure to keep the fair and competitive market environment for BEE development, e.g., the land market, so that to promote the fairness of BEE from the supply side. By increasing the competition in the BEE market, the end-users are benefited by: 1 more choices for BEE products; 2 increased total consumer surpluses in the BEE market.
P3	Given the transaction costs being considered, the developers would choose to reduce the quantity of BEE. In other words, the total market share of BEE would be decreased. Moreover, the higher the transaction costs are, the smaller quantity of BEE the developer would develop. In other words, the developer with lower transaction costs would have a higher market share of BEE.	It justifies the government interventions in terms of reducing the transaction costs for the developers, which also sheds lights to the other stakeholders in the BEE market to get less concern to the uncertainty in terms of transaction costs by the properly designed incentive policies.

From the perspective of TCE, the modeling findings justify the impacts of transaction costs to the developers. A rational developer would choose to develop a smaller quantity of BEE in view of incomplete information, uncertainties, unfair competition, free riders, etc. in the BEE market, in light of transaction costs which may occur. In other words, transaction costs associated with information searching, risk and uncertainties in an information incomplete market would undermine the advantages of BEE. The findings highlight the importance of institutions in the BEE market to secure a level playing field. Attention should not only be paid to government policies, but also to the laws, rules, customs and norms, etc., given the varied contexts in different countries. The results also give references to a wider range of institutions, especially in developing and transitional countries. Take China as an example, as a developing country undergoing quick and dramatic transition from a centrally planned economy to a market oriented economy, the market and regulation system is far from mature. It is quite common that laws and regulations are not fully implemented or enforced, indeed, increasing transaction costs associated with the process of BEE development. It is pivotal, therefore, to foster a well-functioning market and regulation system in China for further promoting the development of BEE.

A further study much detailed research on the impact of specific transaction cost factors and how they affect the decision-making of the stakeholders would be interesting. We also recommend more research to be done along the line of this study to simulate other stakeholders' decision-making process by building game models with considerations of transaction costs factors. It would be a valid contribution for understanding the mind-set of the overall concerns of all the stakeholders and to what extend the transaction costs would affect the decision-makings and thus, how the policies should be addressed to different stakeholders, and hopefully at which stage of the transactions to break the embarrassing black-outs and smooth the BEE market with a better designed policy package that taking transaction costs serious into its consideration.

References

Cournot, A., Recherches sur les Principes Math´ematique de la Th´eorie des Richesses. Hachette, Paris, 1838. English translation by N.T. Bacon, published in Economic Classics, Macmillan, 1897, and reprinted in 1960 by Augustus M. Kelley.

Chan E.H.W., Qian Q. K. and Lam P.T.I., 2009, The market for green building in developed Asian cities—the perspectives of building designers, Energy Policy, Energy Policy, 37(8), 3061-3070.

Coase, R. H., 1937, The nature of the firm. Economics, 4(3), 386–405.ss

Coase, R. H., 1961. "The problem of social cost." *Journal of Law and Economics* 3:1-44.

Gordon R.L., 1994, Regulation and Economic Analysis: A Critique over Two Centuries, Oxford University Press, The Netherlands.

Han Q.D., 2010, Keynote presentation in the sixth international symposium on green building and building energy efficiency, 2010, Beijing, China.

Meyers, S., 1998, Improving Energy Efficiency: Strategies for Supporting Sustained Market Evolution in Developing and Transitioning Countries. Working Paper by Environmental Energy Technologies Division. Lawrence Berkeley National Laboratory, Berkeley, USA.

Organization for Economic Co-operation and Development (OECD), 2003, Environmentally Sustainable Building- Challenges and Policies, OECD Publication Service. Paris, France.

Qian, Q.K., and Chan, E.H.W., 2010, A framework to Appraise The Building Energy Efficiency (BEE) policy in the Transitional China, *2nd International Postgraduate Conference on Infrastructure and Environment*, Hong Kong, 1-2 June 2010 .

Qian, Q.K., 2011, Barriers to Building Energy Efficiency (BEE) promotion: A transaction costs perspective, unpublished PhD thesis, The Hong Kong Polytechnic University.

Qian, Q.K., and Chan, E.H.W., 2011, Barriers to Building Energy Efficiency (BEE) Market- A Transaction Cost (TC) Perspective, *Third International Conference On Climate Change*, 21-22 Jul, 2011, Rio De Janeiro, Brazil.

WBCSD (World Business Council for Sustainable Development), 2009, Energy Efficiency in Building: Business realities and opportunities, Summary Report, available on line at http://www.wbcsd .org/DocRoot/1QaHhV1bw56la9U0Bgrt/EEB-Facts-and-trends.pdf.