BARRIERS TO BUILDING ENERGY EFFICIENCY (BEE) PROMOTION:

A TRANSACTION COSTS PERSPECTIVE

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Barriers to Building Energy Efficiency (BEE) promotion:

A transaction costs perspective

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CERTIFICATE OF ORIGINALITY

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ABSTRACT

Worldwide, buildings account for a surprisingly high 40% of global energy consumption, and the resulting carbon footprint significantly exceeds that of all forms of transportation combined. Large and attractive opportunities exist to reduce buildings' energy use at lower costs and higher returns than in other sectors. These reductions are fundamental to achieving the International Energy Agency's (IEA) target of a 77% reduction in the planet's carbon footprint to meet the desired 2050 baseline, by reaching the CO_2 levels called for by the Intergovernmental Panel on Climate Change (IPCC). This thesis analyzes the concerns of the market stakeholders, mainly real estate developers and end-users, in terms of transaction costs as they make decisions about investing in Building Energy Efficiency (BEE). It provides a detailed analysis of the current situation and future prospects for BEE adoption by the market's stakeholders. It delineates the market and lays out the economic and institutional barriers to the large-scale deployment of energy-efficient building techniques.

Research aim and objectives

The aim of this research is to investigate the barriers raised by transaction costs that hinder market stakeholders from investing in Building Energy Efficiency (BEE). It explains interactions among stakeholders in general and in the specific case of Hong Kong as they consider transaction costs. It focuses on the influence of transaction costs on the decision-making of the stakeholders during the entire process of real estate development.

The objectives are as follows.

(1) To establish an analytical framework for understanding the barriers to BEE investment with consideration of transaction costs, by:

(i) identifying the business barriers to BEE for market stakeholders: the developers and end-users; and

(ii) investigating the stakeholders' transaction costs as business barriers to BEE in the real estate development process.

(2) To build a theoretical game model of decision making among the BEE market stakeholders to explain:

(i) why, at a general level, transaction costs affect stakeholders' decisions in investing in BEE; and

(ii) how the dominant factors of transaction costs affect stakeholders' decisions.

(3) To study the empirical data from questionnaire surveys of building designers and from focused interviews with real estate developers in Hong Kong:

(i) to find out the real market concerns in practice; and

(ii)to identify the transaction costs concerns that are specific to real estate development involving BEE.

(4) To triangulate the study's empirical findings with those of the theoretical model and analytical framework:

(i) to demonstrate how the theoretical game model approach and analytical framework can be used to explain the general workings of the BEE market and also to accommodate specific operations in different institutions; and

(ii) to explore how institutions might help overcome BEE barriers for different market stakeholders in terms of transaction costs and what roles government might play in promoting BEE.

This study uses transaction cost economics (TCE) to investigate the barriers that transaction costs raise for stakeholders who might otherwise develop or purchase BEE buildings. It also develops a theoretical game model to simulate the interaction among the developers and end-users and the logic of their decision-making strategies, which

lay out the rationales for their choices and the influence of various transaction costs. Policy implications are thus drawn from the rationale of decision making by market stakeholders. The conclusions are augmented and reinforced by survey data from building designers, a relatively neutral party in real estate transactions, to show their perspective on green building and energy efficiency in Asia. A comprehensive approach, involving an investigation of all the stages of real estate development and analyzing information gathered in interviews with major real estate developers and their representatives in Hong Kong, is then used to lay out possible negative concerns about transaction costs that would make these actors hesitant to move forward with BEE. The empirical study further explains the game theoretic results and validates the model with qualitative data on actual practices. The study shows that a coherent institutional framework needs to be established to ensure that the design and implementation of BEE policies acknowledge the concerns of market stakeholders by taking transaction costs into consideration. Regulatory and incentive options should be integrated into BEE policies to minimize efficiency gaps and to realize a sizeable increase in the number of energy-efficient buildings in the next decades. Specifically, the analysis shows that a thorough understanding of the transaction costs borne by particular stakeholders could improve the energy efficiency of buildings, even without improvements in currently available technology.

Keywords: Barriers, Building Energy Efficiency (BEE), game model, transaction costs, institution

PUBLICATIONS ARISING FROM THIS THESIS

Journal papers (published or accepted)

1. **Qian Q.K,** Chan EHW & Choy, L.H.T., 2012, Real Estate Developers' concerns about uncertainty in Building Energy Efficiency (BEE) investment - A transaction costs (TCs) perspective, *Journal of Green Building,* accepted for publication. (expected in 4th quarter 2012)
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HONORS AND AWARDS OBTAINED IN DOCTORAL STUDY

(1) **Fulbright Hong Kong Research Scholarship Award** to research in Lawrence Berkeley National Laboratory (LBNL), at University of California, Berkeley and Washington University in St. Louis, USA. (About Fulbright: http://fulbright.state.gov/history.html)

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(4) PEEC[1] Student Scholarship (Stanford University) for Behaviour, Energy and Climate Change (BECC) conference, Sacramento, 14-17, Nov 2010.

(5) United Nations (Headquarters) summer internship in New York, June-Aug, 2010.

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(8) PEEC Student Scholarship (Stanford University) for Behavior, Energy and Climate Change (BECC) conference, Washington, D.C, 15-18, Nov 2009.

(9) NIUS (PolyU) Visiting Scholarship Award to attend International Society for New Institutional Economics (ISNIE) Conference at University of California, Berkeley, winner of the only quota in PolyU in 2009.

(10) Hong Kong Institute of Real Estate Administrators Scholarship 2008/2009, winner of the only quota at PolyU.

(11) PolyU attachment scholarship to research at Lawrence Berkeley Laboratory (LBNL), the University of California at Berkeley, USA.

(12) Guest Researcher, Wuppertal Institute for Climate, Environment and Energy (http://www.wupperinst.org/en), Germany, Sep 2011- Feb, 2012.

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[1] PEEC: the Precourt Energy Efficiency Center, Stanford University
[2] Ronald Coase Institute (RCI): http://www.coase.org/
[3] NIUS: The Network for New Institutional Urban Studies, The Hong Kong Polytechnic University.
[4] PolyU: The Hong Kong Polytechnic University.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

Overview

This chapter provides an overview of the study. It lays out the background of and justification for this research, the research aims and objectives, the research framework, the limitations of the study, and the significance of the research. The summary provides a general presentation of its structure and the findings of the thesis. More detailed analyses and thorough discussions of each part of the study are presented in the chapters that follow.

1.1 RESEARCH BACKGROUND

1.1.1 The Construction Industry

Construction yields an annual output of U.S $4.6 trillion, contributing 8-10% of global GDP, employing a workforce of 120 million people, and encompassing billions of transactions each day (McGraw-Hill Construction, 2008, Qian and Chan, 2011). In the U.S., construction comprises 13.4% of the $13.2 trillion U.S. GDP, of which commercial and residential building construction constitutes 6.1% (Department of Commerce, 2008). The importance of the construction sector is related not only to its size, but also to its role in economic and social development (Crosthwaite, 2000; Ofori, 2003). The European Commission (2006) notes that 11.8 million people are directly employed in the construction sector, which is the largest industrial employer in the fifteen nations (EU-15) that comprised the European Union (EU) before its expansion in 2004, accounting for 7% of total employment and 28% of industrial employment. About 910 billion Euros were invested in construction in 2003, representing 10% of GDP and 51.2% of the Gross Fixed Capital Formation of the EU-15 (European Commission, 2006). In Asia, more than half of the world's new construction is in progress at the time of writing, and that particular building boom is accelerating. China, for example, plans to increase the 30% of its population that is urbanized today to 70% by 2050 and will build some 400 new cities to house 600 million rural-to-urban migrants over that period. That is, China

alone plans to construct new buildings equivalent to twice the number in the United States by 2050.

Up to 50 percent of all energy is consumed by buildings, including the development of materials, construction, and operation. In Hong Kong, for example, buildings consume over half of all energy and about 89% of electricity, mainly for air-conditioning, which is the source of roughly 17% of all Hong Kong's greenhouse gas emissions (CE, 2008; EB, 2008). Southeast Asia ranks third highest in greenhouse gas emissions among the developing nations in the world, after China and India (Sriram, 2007). China and the U.S. rank the highest in greenhouse gas emissions in the world and have already committed themselves to collaborate in the battle against climate change. If the world is to have any hope of mitigating greenhouse gas emissions, it is imperative to maximize the energy efficiency of buildings, moving first toward energy-neutral and ultimately energy-producing ones.

1.1.2 Buildings and Energy Consumption

Buildings have a great impact on energy usage and the environment. Environmentally, the building sector is responsible for high-energy consumption, solid waste generation, global greenhouse gas emissions, external and internal pollution, environmental damage, and resource depletion (CICA, 2002; Zimmermann et al., 2005; Melcher, 2007; Ortiz et al., 2009). In the United States, buildings account for 39% of total energy use, 12% of total water consumption, 68% of total electricity consumption, and 38% of carbon-dioxide (CO_2) emissions[5]. The building industry consumes a substantial amount of resources and has a large impact on the environment (Chan & Lau, 2005; OECD, 2003; Qian et al., 2006; Zhang, 2004). Buildings account for 40% of global energy consumption and nearly one-third of global CO_2 emissions (Levine et al., 2007); the resulting carbon footprint significantly exceeds that of all forms of transportation combined. New buildings that are energy-inefficient are being built every day, and millions of today's inefficient buildings will remain standing in 2050 (WBCSD, 2009). Moreover, the energy

[5] US EPA website: why build green?: http://www.epa.gov/greenbuilding/pubs/whybuild.htm

usage of buildings is growing rapidly as more people move into improved homes and acquire amenities such as heating, cooling, and refrigeration. The International Energy Agency (IEA) estimates that the energy demands of buildings will have grown at an average annual rate of 1.2% between 2008 and 2035 (WEO, 2010), which means that by 2035, the demand by buildings for energy will increase by 38% compared to a base level set by 2008. There is an urgent call for the building industry to contribute its efforts to combat climate change and address environmental concerns.

Since the publication of Our Common Future (WCED, 1987) by the World Commission on Environment and Development, sustainability has become the focus of much attention in all nations. To remain competitive and continue to expand in the future, the building industry knows it must address the environmental consequences of its actions and still meet its economic objectives (Ortiz et al., 2009). The building industry is increasingly seeking innovative materials and solutions that will allow it to build economical, affordable buildings while minimizing the impact of construction activity on the environment.

1.1.3 Opportunity for Building Energy Efficiency (BEE)

Constructing energy-efficient buildings is an essential way to help mitigate climate change, which threatens to have an irreversible, devastating impact on humans. According to the Intergovernmental Panel on Climate Change (IPCC), to confine the average increase of global temperature to two degrees Celsius, we must stabilize the concentration of greenhouse gas emissions at 450 ppm CO_2–equivalent (IPCC 2007; WEO, 2009). This goal places enormous requirements on all sectors to realize deep cuts in greenhouse gas (GHG) emissions. In the building sector, it means, according to the Current Policies Scenario, reducing primary energy consumption by the equivalent of 530 million tons of oil (Million Tons of Oil Equivalent, or Mtoe) (WEO2010). There is a pivotal role that the building sector can play in combating global climate change. In 2035, the building sector has to contribute 30% of the savings in total final energy consumption (WEO2010). It is obvious, therefore, that efficiency improvements in

energy use by the building industry would make a major contribution to meeting such national objectives as improving environmental quality and energy security, reducing the emission of greenhouse gases, increasing energy-efficient investments, enhancing economic productivity and competitiveness, improving living standards, and lowering the local environmental costs of energy supply and use.

There exist many attractive opportunities to reduce the energy use of buildings at lower costs and higher returns than in other sectors. The International Energy Agency (IEA) has called for an overall reduction of 77%, or 48 gigatonnes, in carbon emissions below business-as-usual (BAU) levels for all sectors by 2050 (WBCSD, 2009). Considering both direct and indirect emissions, buildings would have to be responsible for about 18.2 gigatonnes of this 48 gigatonne reduction, with the IEA calling for an 8.2 gigatonne reduction directly through energy-efficient measures applying to buildings. Necessary percentage reductions at an individual-building or sub-sector level may vary considerably from this absolute target, based on geography, climate, economic conditions, and cultural usage patterns. Buildings can also help to reduce the carbon emissions contributed by electrical-power generation by adopting on-site renewable energy and other efficient on-site generation technologies, thereby contributing greater reductions than the 8.3 gigatonnes called for (WBCSD, 2009). Therefore, there is a huge incentive to improve the energy savings of buildings as addressed by different research approaches.

Engineering analyses typically conclude that current practice for new buildings is significantly more energy intensive than is technically necessary and economically optimal (Koomey, 1990; Golove and Eto, 1996; The National Academies, 2010). Some economists respond that the marketplace will choose the appropriate level of energy efficiency that is justified through an assessment of transaction costs, information uncertainty, and risk (Reddy, 1991; Koomey and Sanstad, 1994; Golove and Eto, 1996; Eto et al., 1997; Sathaye and Bouille et al., 2001; Sathaye & Murtishaw, 2004). Both views may be correct. Nevertheless, there are enough justifications for policies to

increase energy efficiency to be fitted into the building market beyond the levels that the market would otherwise choose.

1.1.4 Economic and Transaction costs (TC) Perspective

Some economists (Brookes, 1990; Saunders, 1992; Inhaber and Saunders, 1994) argue that improved energy efficiency may lead energy use to grow more rapidly than it would in a world with fixed technology. Howarth (1997) refutes this argument with an economic production model and concludes that improvements in energy efficiency will not give rise to increased energy consumption unless 1) energy costs dominate the total cost of energy services, and 2) expenditures on energy services constitute a large share of economic activity. Because neither of these conditions is plausible, improvement in energy efficiency will yield a reduction in demand in the long-run compared with fixed technology. Schipper and Meyer (1992) emphasize the importance of grounding energy demand analysis in specific technologies and end-use activities.

Comparisons of discount rates (Koomey, 1990) indicate that the market apparently does not encourage the installation of BEE devices that are extremely cost-effective from society's perspective. Insufficient investment in energy-saving devices may be the result of hidden costs, incorrect parameter specifications, time lags, market failures, or regulatory distortions (Koomey and Sanstad, 1994; Golove and Eto, 1996). Life Cycle Assessment (LCA) and Cost Benefit Analysis (CBA) are both currently popular and well accepted methods in demonstrating BEE as technically efficient and cost-effective (Kotaji et al., 2003; Kats and Capital, 2003). However, many of these studies were conducted by energy-efficiency practitioners rather than academic economists, and they were rather selective in their modeling. They may not fully interpret and reflect the market stakeholders' business concerns.

In practice, improving BEE is complicated due to the many parties and factors involved: the government, the market, a range of technologies, many practitioners, and a variety of cultures. It would be helpful for governments to know how to oversee BEE development most efficiently. BEE studies, though complicated, are necessary for

improving energy efficiency and must involve more than just improving technology. Reports (WBSCD, 2009, Koeppel and Urge-Vorsatz, 2007) show that with currently available technology, the energy-efficiency level could be increased by 30%, yet this does not happen. There must be some underlying reasons that must be addressed and that call for the attention of and collaboration among the key players of governing institutions, based on multi-disciplinary studies that consider economics, politics, society, technology, and so forth.

From the new institutional economics perspective, when transaction costs (TC) are too large, they inhibit exchange, production, and economic growth. The functioning of transaction costs under alternative institutional arrangements is also crucial to the workings of markets (Cheung, 1998; Coase, 1998; Benham & Benham, 1997; North, 1990, 1991). From the perspective of transaction cost economics, energy efficiency is a coordination and incentive problem rather than one of utility maximization (Levine, et al, 1995). This view also emphasizes that policy interventions and different institutional structures may lower transaction costs and provide net social benefits (Golove and Eto, 1996; Levine et al., 1995; Koeppel and Urge-Vorsatz, 2007). Therefore, a better understanding of the nature and structure of transaction costs is necessary to design incentive schemes to change the market mechanisms for BEE investment. In practice, however, transaction costs are extremely difficult to measure and any attempt to determine their absolute value in any particular instance is likely to be problematic (Benham and Benham, 2001). The situation calls for a thorough study focusing on how to smooth transactions for market stakeholders in energy-efficient development, with the aim of lessening the transaction costs involved in BEE transactions.

1.1.5 Focus of this Research

This research mainly focuses on how to smooth transactions among the market stakeholders in energy efficiency development in order to realize the energy-saving target. The study does not focus on any particular type of building technology, but rather on how to marketize energy-efficient buildings to be more acceptable to market

stakeholders and to lessen the transaction costs involved by understanding the barriers to BEE and creating policy packages to encourage such investment. It thus intends to identify key areas where policy initiatives can help address the market's needs for BEE. It is important to note that this research is not meant to specify policy details but to offer an analytical framework for studying the market, with consideration of transaction costs.

1.2 JUSTIFICATIONS OF THE RESEARCH

1.2.1 Multi-disciplinary BEE problems

Energy efficiency in buildings is a complicated issue, which is not primarily about innovative energy-efficient technology, but more about how to put that technology into practice. It thus relates to bigger systemic issues and the need to put into place policies to fit economic requirements and satisfy market stakeholders. BEE involves not only developers, but also many other market stakeholders, such as end-users, suppliers, architects, manufacturers, lawyers, and governments. Often their interests are mutual, and often they are in conflict. For example, to governments, BEE is just one of many policy goals and would affect other policy targets in practice. It requires efforts by all of the parties involved in order to work. Moreover, BEE is related to many concerns of the wider society, including technology, culture, lifestyle, social fairness, consumer behavior, politics, and economic development. Creating a more energy-efficient world will be a difficult task and will not be achieved in the short term. Markets face a big challenge in accommodating energy efficiency. It is essential to have a thorough understanding of the BEE market and the needs of stakeholders, so that an effective policy package can be put in place to promote BEE.

Moreover, BEE also involves each nation's local property policies, energy and environment policies, energy-pricing systems, and welfare systems. Thus, to be able to improve BEE, it will inevitably require that the whole society and polity work together. It will also require taking into account different social, political, cultural, and institutional systems within each individual country.

1.2.2 Integrated Research on BEE

Currently, the research relating to BEE is fragmented, with multiple studies, each focusing on just one or a few aspects of BEE, such as a cost-benefit analysis to determine whether a certain type of technology is cost-effective. These studies are valid and contribute to our understanding of BEE development from a variety of perspectives and applied to a range of problems and locations. However, most research has been done from a singular perspective looking at just one form of technology, a single market or government. Few look at BEE as a whole to study the underlying concerns of market stakeholders and to explore how the government could develop policies with those concerns in mind. It is thus critical to look into the BEE market from more than one perspective to get an overall idea involving more than one party, including the government and market stakeholders such as developers and end-users, and to study how they interact. The quest for BEE will proceed more efficiently if they better understand one another's decision-making strategies.

1.2.3 The Bottom-up Approach

The nature of decision-making about energy use in buildings makes it important to take a bottom-up approach to identify the barriers to energy efficiency and the means to overcome them, rather than proposing top-down prescriptions based on economy-wide data and analysis. It is necessary to understand the market concerns of the stakeholders at different stages of transactions. This bottom-up analysis must be applied to individual building sub-sectors, based on the specific characteristics of their energy use. Therefore, microanalysis of BEE is important and justifies the game-theoretic model applied in this research to understand their interests and responses to market situations in details.

1.2.4 Considering Transaction Costs to Developers and End-users

In terms of research methodology, many cost-benefit analyses do not consider transaction costs, thus they are not isomorphic with the real market. Furthermore, most research does not consider the effects of transaction costs on the different market

stakeholders' choices involving BEE before making a policy recommendation. It is important to take into consideration the transaction costs involved in each party's exchange calculus and to understand their concerns about TC when they make decisions about BEE investments.

Different sectors of the building industry, such as commercial office, hotel, and residential buildings involve different investment strategies for occupancy and operation that affect the strategy for achieving BEE. This research chooses to concentrate on the largest subsector of buildings- residential sector, based on total energy use, which normally involves property built by developers and sold to own-occupiers. It accounts for around 40% or more of all energy used in buildings of all types (WBCSD, 2009). This study considers the transaction costs incurred by the stakeholders at each stage of real estate development.

1.3 MOTIVATION OF THIS RESEARCH

The motivation for this research starts with an observation of the market's reluctance to embrace building energy efficiency while the government's current policies seem to have failed to effectively promote BEE. This research investigates the underlying concerns about and reasons for market stakeholders to invest in BEE during the real estate development process from a transaction costs perspective. It provides a detailed study of the business barriers to BEE – that is, market, economic, institutional, and policy impediments in terms of transaction costs from the perspectives of real estate developers, end-users, and the government during the process of real estate development and purchase. A game-theoretic model has been built to simulate the strategies of stakeholders with and without attention to transaction costs. An empirical study of the BEE market stakeholders of Hong Kong and Singapore verifies the theoretical framework in general and explains the exceptions that exist in the real world. By bridging the gap in our understanding of the concerns and constraints of both the market and the government, and by developing a broader dimension of cost (e.g., transaction costs in terms of risk, delay, uncertainty, and other hidden costs), the

government could intervene at the most effective point, or assist the most vulnerable party in the market at the most appropriate moment.

1.4 RESEARCH AIM AND OBJECTIVES

The aim of this research is to investigate the barriers raised by transaction costs that hinder market stakeholders from investing in BEE. It explains interactions among stakeholders in general and in the specific case of Hong Kong as they consider transaction costs. It focuses on the influence of transaction costs on the decision-making of the stakeholders during the entire process of real estate development.

The objectives are as follows.

(1) To establish an analytical framework for understanding the barriers to BEE investment with consideration of transaction costs, by:

(i) identifying the business barriers to BEE for market stakeholders: the developers and end-users; and

(ii) investigating the stakeholders' transaction costs as business barriers to BEE in the real estate development process.

(2) To build a theoretical game model of decision making among the BEE market stakeholders to explain:

(i) why, at a general level, transaction costs affect stakeholders' decisions in investing in BEE; and

(ii) How the dominant factors affect stakeholders' decisions.

(3) To study the empirical data from questionnaire surveys of building designers and from focused interviews with real estate developers in Hong Kong:

(i) to find out the real market concerns in practice; and

(ii) to identify the transaction costs concerns that are specific to real estate development involving BEE.

(4) To triangulate the study's empirical findings with those of the theoretical model and analytical framework:

(i) to demonstrate how the theoretical game model approach and analytical framework can be used to explain the general workings of the BEE market and also to accommodate specific operations in different institutions; and

(ii) to explore how institutions might help overcome BEE barriers for different market stakeholders in terms of transaction costs and what roles government might play in promoting BEE.

1.5 RESEARCH QUESTIONS UNDER EACH OBJECTIVE

- **To understand the barriers to BEE investments (with consideration of transaction costs)** to different stakeholders: developers, end-users, and government during the real estate development process. **(Chapters Three and Five)**

  1) What are the business reasons, market obstacles, and other factors that help to affect the development of green buildings and energy efficiency? (To be addressed by the market survey in Chapter 5.)

  2) What types of barriers exist in the BEE market? (To be addressed by the literature review in Chapter 3.)

  3) What are the barriers for BEE for different market stakeholders during the real estate development process? (To be addressed by the interviews in Chapter 5.)

  4) How are those barriers identified as affecting particular stakeholders connected to transaction costs during the real estate development process? (To be addressed by the literature review in Chapter 3 and the interviews in Chapter 5.)

- **To build a theoretical game model of decision making** to simulate the interactions between the stakeholders of BEE, with consideration of transaction costs. **(Chapter Four)**

    5) What are the outcomes of the game between developers with consideration of transaction costs under different market conditions?

    6) What are the outcomes of the game between the developers and end-users with consideration of transaction costs under different market conditions?

- **To study the empirical data from questionnaire surveys of building designers and from focused interviews with the real estate developers in Hong Kong. (Chapter Five)**

    7) What are the barriers to BEE for real estate developers during the real estate development process?

    8) What extra work arises from barriers at different stages of BEE development in real practice?

    9) What are the corresponding transaction costs specific to different stages of BEE development in real practice?

- **To triangulate the findings of the empirical study with those results from the theoretical model and analytical framework. (Chapter Six)**

    10) How do the theoretical findings fit the empirical case studies? How far can the theoretical game model and analytical framework explain the working of the BEE market in the real world?

    11) How do the interviews and questionnaire survey results echo the findings of the theoretical game model and analytical framework?

    12) How might institutions, in the Hong Kong case, help to overcome these BEE barriers in terms of transaction costs for different market stakeholders?

13) What roles can government play via the establishment of institutional rules to promote the BEE market?

1.6 DELIMITATIONS OF THE STUDY

The purpose of this section is to confine the boundaries and define the parameters for the study. This study is to explore business explanations for the lack of motives and incentives for BEE investment to gain a better understanding of the deficiencies in current BEE policies. This research chooses to concentrate on residential sector- the largest subsector of buildings based on total energy use. It considers the policies, construction options, financial considerations, transaction costs, risks, and behavior directly relevant to the residential sector only.

This work recognizes that using more grid electricity from non-fossil fuels (such as solar, wind, hydro, and nuclear) will help to address climate change. However, the contribution of non-carbon fuels is likely to be constrained for several decades. Cutting energy consumption is also vital because it helps to preserve finite resources, lowers costs for businesses and consumers, and can be accomplished relatively quickly. This research concentrates on energy used in buildings during their life cycle. This study is conducted from a transaction-costs perspective to determine market concerns involving hidden costs, which discourage investments by stakeholders in BEE given the current level of available technology.

1.6.1 Building Energy Efficiency

This thesis focuses on the efficient use of energy in buildings, based on the overriding purpose of improving the interests of market stakeholders in investing in energy efficiency. Energy is valued for what it enables rather than for itself. In other words, people do not want more energy, but more of the services provided by energy: heating, cooling, lighting, and communicating. In fact, people are happy with less energy consumption as long as the energy consumed provides the same level of services and keeps their living standards at a comfortable level. However, because energy is not

intrinsically valued, conserving energy tends to be a low priority for most building owners and developers.

This research acknowledges that building energy-use is part of a complex system that includes transportation and urban planning and has major social consequences other than climate change. The energy mix is also important in determining carbon-dioxide emissions. However, this project focuses primarily on energy used in the construction and occupation of buildings.

This project focuses on energy use in buildings and does not cover many other important aspects of sustainable building, although it does cover the main agenda of green building (GB). The energy implications of building materials, technology development, transportation, water use, and food choices can be as important as the direct energy savings of buildings, and although they will be considered in this study through the collection of views about options for building design and construction processes, any detailed study of these areas is beyond the scope of this project.

1.6.2 Transaction costs

Despite the many advantages of using a transaction-costs perspective for this study, the deficiencies of TC studies identified by North and Williamson[6], including such difficulties as quantifying TCs, also apply to this study. Because transaction costs are difficult to measure and are easily affected by many social factors, this research has been an on-going project that is mainly theoretical. The research mainly focuses on the extra transaction costs caused by investment in BEE compared to its traditional counterparts. The common transaction costs that flow equally from BEE and traditional buildings are assumed in this research, but not as the key concerns discouraging stakeholders from investing in BEE.

[6] "Transaction costs are extremely difficult to measure and determining their absolute value in any particular instance is likely to be problematic" (Williamson, 1979, P233, Sorrell et al., 2004)

1.6.3 Game model

Game models (GM) assume all players to be rational actors; in reality, the players in a market may have only limited rationality and may consider more factors, such as the environmental, societal, social welfare, safety, and personal preferences, than can be considered in the game model. A good example here is that the comfort level brought by BEE may not be quantifiable as a benefit and put into an appropriate function.

In the game model, only economic utility in terms of cost value can be considered in the playing out of the utility functions of developers as compared to one another and of developers and end-users in their exchanges. However, in the real market, BEE would also bring other utilities, which may not be quantifiable, utilities such as the improvement of the living environment, greater comfort, the reputation of a company brand name, and social responsibilities.

In the game model, the players' assumptions are based on their complete rationality, although this is not the case in the real world. The TCE approach, in contrast, emphasizes the limited rationality of human beings, which contradicts the assumption of the game model. The game focuses on both the demand side and the supply side of BEE transactions.

Hong Kong, as an international and well-developed city, has been chosen in this research to exemplify the generic findings of the game model concerned with the market barriers to energy efficiency. It would be better to have more than one such mature market to ascertain if the game produces generic results that represent most or all developed markets. Further research could be done along this line with more cases of developed cities or, in contrast, using underdeveloped cities to see how applicable the theories are and how they could be applied to a wider range of cases.

1.7 ORIGINALITY AND SIGNIFICANCE OF THE RESEARCH

Improving energy efficiency has become an increasingly urgent imperative across the world. It is my hope that this research can contribute to the further generation of new ideas and approaches on how to increase the market share of BEE investment.

This research comprehensively analyzes the market barriers to BEE from the perspectives of the developers, the end-users, and the government. By applying the methodology of TCE, it focuses on the BEE market barriers caused by TCs that discourage stakeholders in the market for real estate development from entering the BEE market. It uses a game theoretic model to simulate the market stakeholders' strategies for investing in BEE with and without TCs. The game model provides a certain degree of confirmation that TCs are too important to be ignored in research into BEE and provides a very detailed analysis for scenarios with and without TCs being taken into consideration. Based on the theoretical game model and the framework developed from the literature review, the study also collects empirical data to seek for support from, or provide explanations of, some exceptional real-world situations that the theories and models cannot explain. Moreover, with an in-depth understanding of market interactions among the developers and end-users from a transaction-costs perspective, some key recommendations and policy implications can be drawn by triangulating the findings from the above analyses. Both the common results from the triangulation and the exceptional findings will be explained.

1.8 STRUCTURE OF THE THESIS

This thesis consists of seven chapters:

Chapter One introduces the background of the study and identifies and justifies the main areas of research. In this chapter, the aim and objectives of this study are set out in detail.

The remaining part of this dissertation is organized as follows:

Chapter Two elaborates the research methodology and the use of game models, and provides details of the survey and the measurement instruments applied in this research.

Chapter Three provides a thorough literature review on the TCA framework, the BEE market, market barriers, and the real estate development process. It explores the barriers of BEE to the market stakeholders and the relevant transaction costs caused by the barriers. It then reviews how the TCA framework can be applied to the developers' concerns about BEE investment decisions and how institutional and government policies could help to increase BEE.

Chapter Four proposes a game-theoretic model to simulate the decision-making process among the real estate developers and the end-users given their options for energy efficiency or otherwise. It will analyze the existence of transaction costs and their effect on the market, and on stakeholders' decision-making and the rationales behind it.

Chapter Five presents the analysis of a set of interviews with real estate developers in Hong Kong to verify how well the theory fits actual practice. The findings of the quantitative analysis of the market survey of building designers are also presented here.

Chapter Six is based on the findings of empirical studies and discusses to what extent their hypotheses are addressed; it also discusses the institutional issues and policy designs suggested by the triangulation analysis of the findings presented in the previous chapters. It also provides a summary of the dissertation and discusses its contributions and limitations, together with implications for future research and practice.

Chapter Seven is the conclusions.

The overall research framework and logical flow of the study are summarized in Figure 1.1.

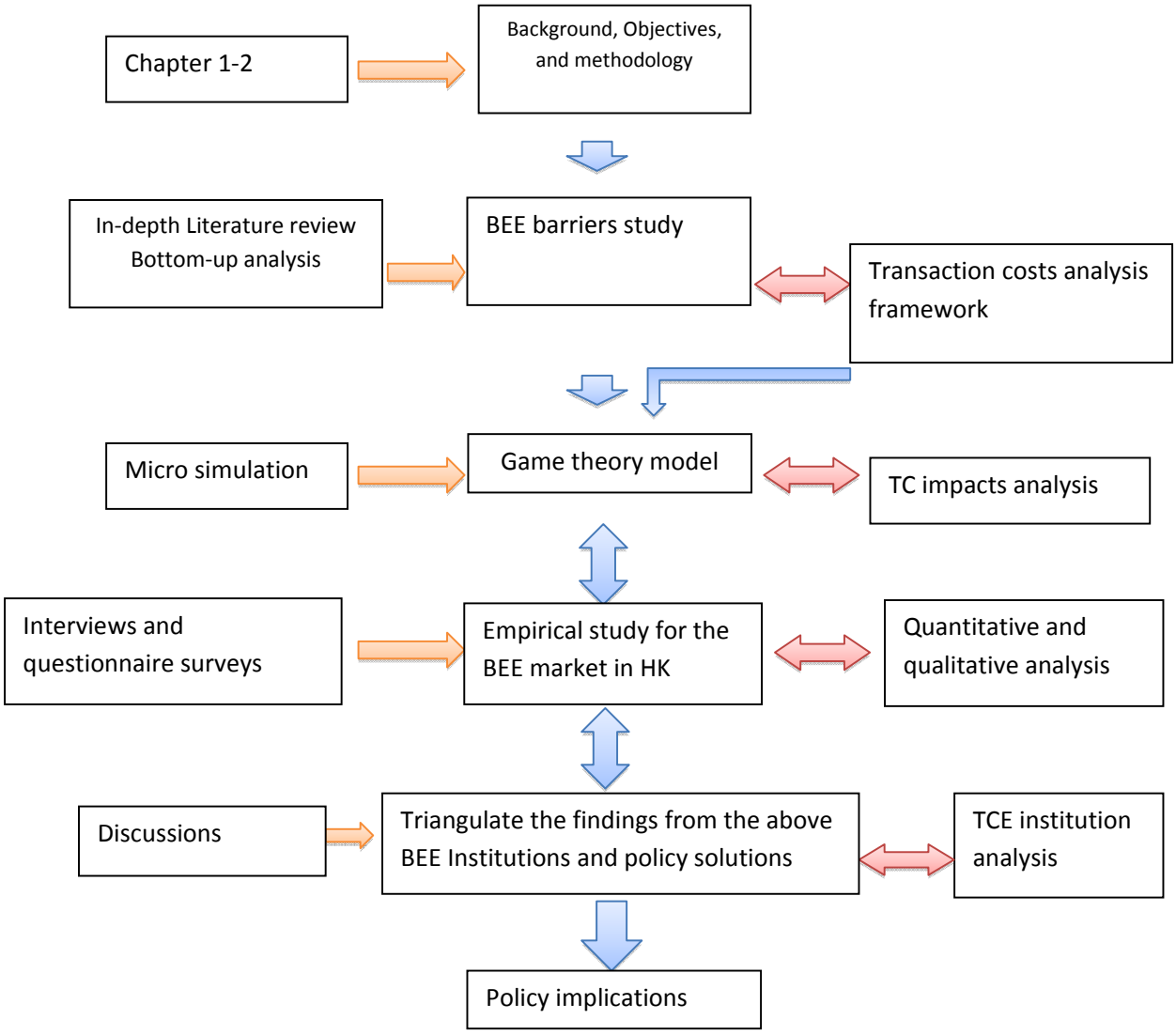

Figure 1.1 Research Framework and Work Flow

CHAPTER TWO: METHODOLOGY

Overview

This chapter explains the methodologies applied in this research and how they work together to best serve the purpose of this thesis. This research relies on the relevant literature to provide background on transaction cost considerations and the market for BEE. It is followed by a game-theoretic model that mimics the mind-set of the real estate developers and the end-users facing choices involving BEE investments. An empirical study with questionnaire surveys and interviews is used to verify the theoretical propositions and to explain the exceptions that exist in the practical world. Triangulation analysis is applied in this research to integrate the findings from the qualitative and quantitative research, to corroborate the conclusions, and inform the discussion and recommendations.

2.1 RESEARCH DESIGN

A research design is a detailed plan outlining the critical steps to be followed by a researcher when conducting a study (Monette et al., 2002). The major function of a research design is to secure relevant evidence to answer the research questions, to test theories and hypotheses, or to explain particular phenomena (Kerlinger and Lee, 2000; De Vaus, 2001). Preparing a research design often includes, for example, consideration of what approach to use, what kinds of relationships exist among different research methods, how various methods might be supplemented to serve the research aim, and how to collect empirical data and choose respondents.

2.1.1 Level of Constraints for this Study

Most of the research literature evaluated in this study has been limited to a specific issue. The research has focused on isolated areas, ignored circumstantial factors, and made fundamental assumptions about human behavior in business transactions. The methodologies used have left wide gaps to be bridged. This study has not been bound by any particular orthodox research methodology, but has adopted a holistic approach

calling for theoretical and practical considerations of several phenomena, such as market barriers, transaction costs, and BEE real estate development practices. This study requires a combination of appropriate methods. In order to establish the best research approach to meet the purposes of this study, the levels of constraint relevant to its stated purposes have had to be identified. The analysis of the levels of constraint for this study is illustrated in Table 2.1.

Table 2.1 Analyzing the Level of Constraint for this Research

Research Types	**Naturalistic observation** (Lowest level of constraint)	**Case study method** (Lowest level of constraint)	**Correlational research** (Medium level of constraint)	**Differential research**[7] (High level of constraint)	**Experimental research** (Highest level of constraint)
Characteristics	*Observation of subjects in their natural environment.*	*Involves moving the subject into a moderately limiting environment, intervening to a slight degree and observing the subject's responses*	*Focuses on quantifying the degree of relationship between two variables* *(Relies on quantitative data analysis)*	*Two or more pre-existing groups of subjects are compared. The setting is usually highly constrained, and the measurement procedures carefully defined and precisely followed.*	*More constrained than differential research in that the subjects are randomly or in some other way assigned without bias to the various groups or conditions in the study.*
Applicability to this study	**Not Applicable**	**Applicable** Provide case scenario to interviewees and explore their opinions towards issues relating to the case scenario	**Highly Applicable** Questionnaire survey to targeted samples to collect data and then carry out statistical analysis	**Not Applicable**	**Not applicable**

Note: Sections in italics are adopted from Graziano (2001), in Chan (1997) [8]

[7] Quoted in Chan, M.W., The relationship between project funding and construction systems, PhD Thesis, Imprint Hong Kong: University of Hong Kong, 1997, p. 71. Quoting Hayman (1964).

[8] Graziano, A.M., *Research methods: a process of inquiry*, 4th Ed., (Boston: Allyn and Bacon, 2001), p. 456. Qouted in Chan, M.W., The relationship between project funding and construction systems, PhD Thesis, Imprint Hong Kong: University of Hong Kong, 1997, p. 71.

2.2 RESEARCH METHODS

This study is at a low to medium level of constraint (Table 2.1). It is suitable to use interviews and survey, as the two major methods of data collection. More details of the research design and methods used in this study are presented below.

2.2.1 Literature review to establish groundwork

A substantial literature review has been conducted in this research, as presented in Chapter 3, to explain the market issues regarding BEE. It gives an overall picture of the barriers to BEE, which are caused by both internal features of the real estate market and external factors, such as policy failures, individuals' behavior, and culture, etc. The review separates these barriers into different stages of the real estate development process and matches them with possible transaction costs. This provides a solid foundation for the BEE market study to present the subsequent chapters in a logical flow. In addition, this work has involved extensive research on the role of governments around the world and how they typically promote BEE. This provides insights for the following chapters, which propose policy solutions to promote BEE.

2.2.2 An analytical framework based on Transaction Cost Economics (TCE)

Transaction cost economics argues that markets and organizations provide alternative means of organizing economic activities and that the choice between them depends upon a number of factors, including the relative magnitude of transaction costs (Williamson, 1979, 1985). In common with orthodox economic theory, TCE explains the behavior of individuals rather than social structures and assumes these individuals to be rational actors in that they seek out opportunities to improve economic efficiency. In common with agency theory, TCE attaches particular importance to asymmetric information and opportunism. However, TCE extends the orthodox/agency framework by first introducing the behavioral assumption of bounded rationality, then focusing on the natures of different transactions and the costs and risks associated with them, and third, explaining why particular types of transaction are associated with particular types

of governance structures (Sorrell et al, 2004). This research applies TCE to study the underlying reasons why the market is reluctant to accept BEE by choice. The findings help establish the study's later discussion on how to choose a particular governance structure to solve the existing problem.

In practice, transaction costs are notoriously difficult to measure, with the result that "… there is a suspicion that almost anything can be rationalized by involving suitably specified transaction costs" (Williamson, 1979, Sorrell et al, 2004). Instead, this study chooses to focus upon the determinants of transaction costs, their relative size in different circumstances, and how they can be minimized by the choice of an appropriate governance structure. For the purpose of this research, TCE provides a comprehensive framework through which to understand the stakeholders in the real estate market in general and the BEE market and its barriers in particular.

2.2.3 Simulation of decision-making process with a Game-Theoretic Model

Many decisions are made and contracts signed in the course of real estate development, and many stakeholders with mutual and conflicting business interests enter into dealings with one another. It would be interesting to apply a game theoretic model to simulate the behavior of these stakeholders during their decision-making about BEE to better understand the important factors that help promote energy efficiency. As presented in Chapter 4, this research uses such a game model to offer a theoretical illustration and explanation of the mind-set and decisions of the stakeholders. The game model is designed to simulate two scenarios; one is the game among real estate developers themselves, and the other is a game between the developers and the end-users. In each scenario, the actors face choices about BEE. In each scenario, the game model has three levels; the first level is the simple ideal market, without any transaction costs; the second level is a more practical market, which includes transaction costs as a consideration during the decision-making process; and the third level presents the transaction costs in greater detail to determine how different transaction costs and their attributes affect the decisions of each player in the game.

The static Cournot competition[9] model is used for the game between two developers. This is because in a BEE development process, all the real estate developers are unaware what the market demand for BEE will be at the time the BEE project is completed. It is difficult to tell who leads in BEE investments and who follows the trend. Therefore, it is more reasonable to assume that the developers invest in BEE spontaneously and independently. The Cournot Game Model is thus an appropriate selection for simulating the interactions between two real estate developers.

The Nash bargaining model[10] is used to simulate the game between the developer and the end-user. This model assumes that the real estate developers and the end-users have individual estimations of a particular BEE product. Their estimates are based on their expectations and preferences, the product's affordability, and other constraints. The BEE product price is eventually set through the negotiation of the parties in the market, and the transaction occurs. The selection of this model is based on the following considerations, which fit the assumption and features of the Nash bargaining game well: (1) In reality, the micro-transaction of BEE actually takes place between one developer and one end-user. In other words, the final property contract is signed by one developer and one end-user when the BEE product is sold. (2) The entire BEE market could be

[9] A Cournot competition is an economic model named after Antoine Augustin Cournot (1801-1877), who observed competition in a spring water duopoly. The model is used to describe an industry structure in which companies compete in the amount of output they produce, an amount they choose independently of one another and simultaneously. The features include the following: (wiki: Cournot competition, at http://en.wikipedia.org/wiki/Cournot_competition)

1. There is more than one firm and all firms produce a homogeneous product, i.e., there is no product differentiation;
2. The firms do not cooperate, i.e., there is no collusion;
3. The firms have market power, i.e., each firm's output decision affects the price of goods;
4. The number of firms is fixed;
5. The firms compete in quantities, and choose quantities simultaneously; and
6. The firms are economically rational and act strategically, usually seeking to maximize profits given their competitors' decisions.

[10] Recently the Nash bargaining game has been used by some philosophers and economists to explain the emergence of human attitudes toward distributive justice (Alexander, 2000; Alexander and Skyrms, 1999; Binmore, 1998, 2005). These authors primarily use evolutionary game theory to explain how individuals come to believe that proposing a 50-50 split is the only just solution to the Nash Bargaining Game. (wiki: Nash bargaining game, at http://en.wikipedia.org/wiki/Nash_bargaining_game)

abstractly described as a game played by a suppositional real estate developer and a suppositional end-user, who are aggregated to determine the entire demand from end-users and supply from developers in the real estate market. The quantity of the BEE product and its price are eventually set by market forces. Hence, the result of the game could have policy implication with the rationale being to expand the market penetration of BEE.

2.2.4 Quantitative questionnaire survey

A questionnaire survey was designed to elicit the opinions of building designers in Hong Kong and other places in Asia regarding the market barriers to green buildings and energy-efficient building developments. The survey was conducted[11] to the building designers who have connections with them and are actively involved by the BCI group in the industry in 2007. The author discussed with the survey's instigators of the BCI the rationale of the survey and obtained their consent to use the data set. Part of the survey was previously published with BCI's consent (Chan et al, 2009, Qian and Chan, 2010). Further discussion with their researchers helped to identify the appropriate subset of the survey's questions to be used for this PhD study. This part of the research uses the data collected from Hong Kong and Singapore only. The findings of the questionnaire survey to the buildings designers show the business environment and market expectation on green building development. It includes both Hong Kong and Singapore to generalize the findings to a wider implication regarding to the issue. The responses from building designers are important to understand the market/business expectation from a more objective perspective.

<u>Why focus on Hong Kong and Singapore?</u>

[11] The BCI Group of Companies is the leading construction media group in Asia Pacific. With BCI Asia and BCI Australia, the group operates more than 20 offices in Southeast Asia, Greater China, and Australia. BCI is a community organizer for the region's construction industries, providing magazines, information systems, events, project leads, and consultancy services. Dr. Matthias Krups is Chairman and CEO of the BCI group.

As a generic study of the BEE market, this study is intended to generalize the localized research to a wider area. Hong Kong and Singapore, as international cities, have the unique attribute of being free markets with relatively highly developed market systems, transparent information, and fair policies, etc. To avoid, as much as possible, being tainted by side issues such as unreliable legal systems, rigid centrally planned economies, corruption, and unfair competition, etc., Hong Kong and Singapore are deemed suitable choices to represent regions that are economically well developed with a free market and well-educated professionals. Besides, Hong Kong and Singapore both have few seriously distorting factors such as political intervention and contract credibility. The case studies of Hong Kong and Singapore will also reflect well on those localities, which have similar market backgrounds, and also on those areas developing their own relatively weak markets.

Why building designers are brought into focus

Many participants in the building market may be potential stakeholders involved in green building and/or energy-efficient products. Some stakeholders, such as contractors or developers, may focus on one aspect of green buildings; a developer, for example, might focus on profit margins, and a contractor on low construction costs. This part of the study is carried out from the perspective of building designers, who deal with developers, contractors, government regulatory bodies, and the public-end-users. Their roles and business interests in creating and delivering green buildings are relatively neutral; thus, they provide a link with a more objective view between the government and the market.

Target respondents and sample selection

A questionnaire survey was conducted by BCI in 2007. The targeted respondents, mainly building designers and architects who are senior professionals in active practice in the construction industry, were extracted from the BCI database. The total numbers of registered architects in Hong Kong and Singapore were about 2300 and 2000 respectively (HKIA, SIA website). 1338 questionnaires were sent to practicing architects

who had, or whose company had, a contract with BCI and who were active in the construction industry in Hong Kong, and 1397 were sent to an analogous group in Singapore. The number of questionnaires sent out totaled more than half the number of architects in these two cities; hence the intended coverage was considered adequate. Of these, 112 and 103 questionnaires were returned, respectively, with valid return rates of 8.37% in Hong Kong and 7.37% in Singapore.

As green building design and its market is relatively immature, comparing to its traditional counterpart, many building designers may not have the experience or knowledge in green building practice, which leads to a lack of professional capacity to answer all the technical questions designed in the questionnaires. This may be the main reason for the low response rate. However, on the other hand, we could assume that those who have sent back the questionnaires and been participated in this survey are those who actually have the knowledge and confidence in answering the questions.

The design of the questionnaire

The questionnaires were designed to solicit the perceptions of building designers about the economic issues of green building in both cities. The three main questions involved "business reasons that drive the market", "market obstacles", and "favorable factors that attract business" and were intended to explore market functions and problems. As the building designers were considered to be relatively neutral in that they worked with most of the stakeholders in the construction process, their perceptions are an important reference for government policymaking and good guidance for other stakeholders.

2.2.5 Qualitative interview with real estate developers

As a supplement to the data set obtained from the survey of the building designers' perspective, in-depth interviews with the executives and architects who work in big real estate development firms in Hong Kong solicited their views on issues regarding BEE investment. The interviews selected were with 15 top managers or directors who actively worked in major real estate development firms or architectural firms, which

covered 80% of real estate activities in Hong Kong. Their views and opinions reflect their preference to current BEE development in practice, which directly and indirectly reflect their will if and how to achieve the BEE decision-makings. Their opinions have a very heavy weight to influence the other real estate developers and stakeholders in the BEE market and affect the development of BEE market. Therefore, the findings of the interviews serve the research purpose and have its significance. The purpose was to get the perspectives of real estate developers and to check the assumptions and findings about BEE market barriers in the literature review and the game-theoretic model. It also provided a way to check the findings from the questionnaire survey through a triangulation analysis to provide a better picture of BEE market development issues relating to a specific institution in the Hong Kong case. It thus provides a reference for designing rational policy.

2.2.6 Comparison of interviews and Questionnaire Surveys

Table 2.2 offers a simple yet comprehensive comparison of interviews and questionnaire surveys in a data-collection strategy.

Table 2.2 Comparison of Interview and Questionnaire Research Methods

	Interviews	**Questionnaire surveys**
Advantages	- More interaction between interviewer so that more information about the survey can be obtained. - Interviewer can pre-select respondent to match the population profile. - In-depth information can be obtained. - Ambiguities about the survey can be explained.	-cover wide geographical locations without significant increase in costs. - rapid data collection process -offer cheapest option -allow respondents time to think about questions -can ensure anonymity of the respondents
Disadvantages	-longer period needed in the field collecting data. -follow-up is labor intensive -some respondents are unwilling to talk to strangers. -Questions may be altered or respondent coached by interviewers.	- low response rate in some modes. - no interviewer intervention available for probing or explanations. - cannot be too long or complex. -directions/software instruction for progression through the instrument.
Remarks for this study	NOTE: In this study: it has benefited from all the advantages of using interviews. This study has not suffered from the following inherent disadvantages: -some respondents are unwilling to talk to strangers. (because the respondents are very senior professional in the field and agree to discuss on the topic in advance) -Questions may be altered or respondent coached by interviewers. (because the respondents are much more knowledgeable on the practice issues than the interviewer)	NOTE: In this study: it has benefited from most of the advantages of using questionnaire surveys. It acknowledges the inherent disadvantages, but they do not affect the survey results because the survey uses a large sample size. The target samples are known to have relevant knowledge before they are contacted for survey.

Source: adapted from Cooper & Schindler (1998)

The above strategies justify this study's choice of the two research methods of survey and interviews. In addition, there are other reasons to include both survey methods in this research. First, the survey of building designers in Hong Kong and Singapore, typical international cities, provides a more generic set of insights into the BEE market, and second, interviews with the Hong Kong real estate developers and their representatives takes a closer look at the specifics of the local situation. It also contributes to a determination of the extent to which the local case mirrors the generic results, albeit with much deeper insights.

2.2.7 Triangulation analysis with both qualitative and quantitative results

Chan (2002) summarized the triangulation strategy of integrating survey and fieldwork and combining quantitative and qualitative research approaches, which has been employed since the 1950s, particularly in policy research (Chan, 1997, 2002; Shapiro, 1955). In the words of Csete and Albrecht (1994), triangulation reaps the 'best of both worlds'. The quantitative data analysis supplements the analysis of qualitative data derived from fieldwork. Thus, the fieldwork and qualitative data become more useful and meaningful when interpreted in the light of critical quantitative information, just as statistics are more useful when compared with content analyses or interviews (Jick, 1979). Triangulation, in this respect, can lead to a prominent role for qualitative evidence. The strategy can be employed for within-method cross-checking and between-method checking (validity checking of the qualitative results and quantitative data analysis) (Webb, 1966; Weber, 1933). In this study, the quantitative questionnaire method was adopted to elaborate on the findings of the primarily qualitative study, which is one of the four triangulation models suggested by Steckler (1992). Figure 2.1 shows the triangulation model for this study.

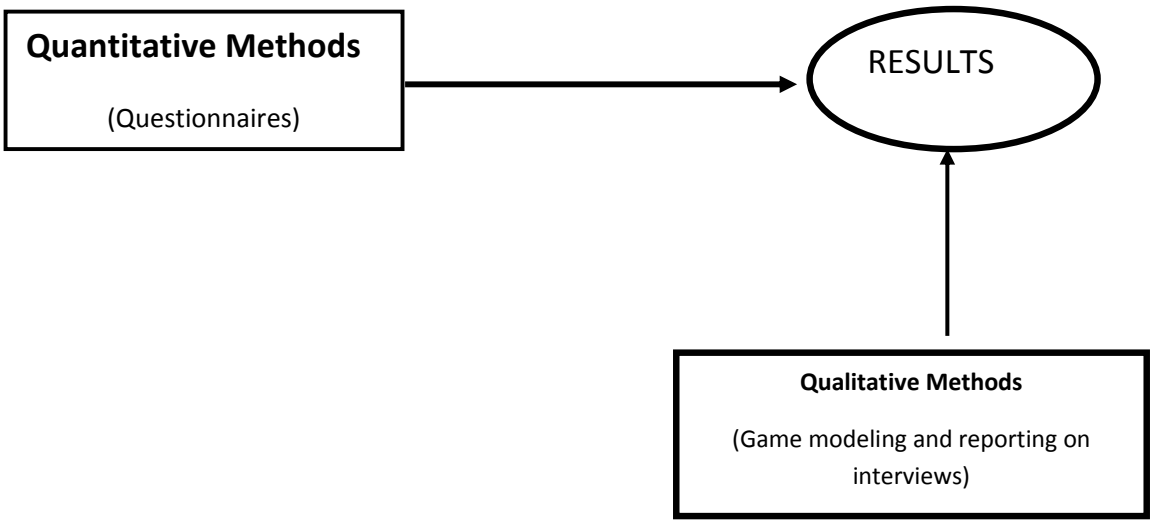

Figure 2.1 Triangulation Model for the Study

To summarize the research methodology of this study, Figure 2.2 shows the relationship and processes of the different research methods adopted for this study and indicate the key issues that are addressed under each method.

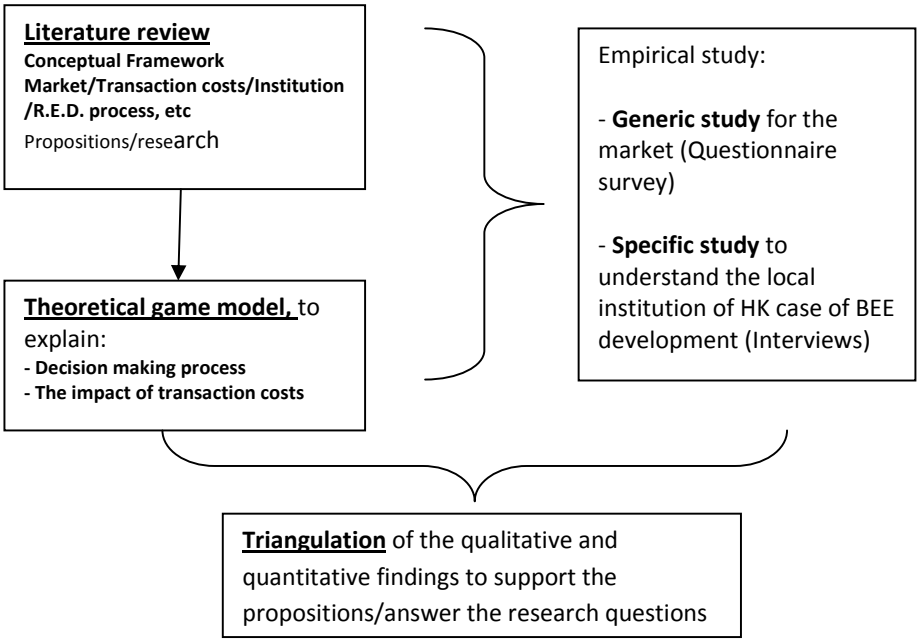

Figure 2.2 Roadmap of the research design and methodology

CHAPTER THREE: LITERATURE REVIEW

Overview

This chapter provides an in-depth investigation of barriers to BEE development. A framework is established to better understand the barriers to BEE. The identified barriers are assigned to different stakeholders at different stages of the real estate development process to further examine their specific influence on particular stakeholders at particular stages. The Transaction Cost Economics (TCE) literature is explored to link market barriers with specific transaction costs, so that TCE theory can be used to explain the BEE market problem in a theoretical way. This chapter also reviews the green-building market that embraces BEE elements in order to identify the hurdles impeding BEE promotion in the marketplace. The role of government is critically reviewed to see how government could help address those hurdles. With a thorough understanding of the literature, research questions and propositions are proposed for the subsequent empirical study. This chapter provides a solid theoretical foundation for the game-theoretic model and empirical studies that follow. An understanding of existing theories in the literature also contributes to the discussion of policy implications in the final chapters of this thesis.

3.1 RESEARCH SUBJECTS AND THEIR INTERRELATIONS

Current BEE research is either focused on pure technology from an engineering point of view or on government policy, generally in a cost-benefit analysis. These two different approaches both suggest that BEE is beneficial to most of the market stakeholders, as well as to society. Although the net benefit for society has been known for a long time, many steps toward energy efficiency have not been taken (Koeppel and Urge-Vorsatz, 2007). The stakeholders still seem to hesitate about voluntarily entering the BEE market. This may be due to certain characteristics of the market, technologies, and end-users who reject rational, energy-saving choices in the purchase and use of appliances during the life-cycle of a building. It justifies a critical review of the current market situation that addresses BEE development. Given the current sophistication of technology, a

better-designed policy package to promote BEE could increase effectiveness and efficiency by 40% (OECD, 2003). Therefore, there is a great potential in studying the stakeholders' concerns and the barriers that affect BEE investment.

Economic theories suggest that market structure and performance is determined by the ease of entry and exit (Baumol et al., 1982). Compared to conventional building, the barrier to the BEE market is higher because of greater capital costs, new information, new technology, financial risks, and so forth. If there is asymmetric information about quality standards or requirements that are not mandatorily imposed on the market, the opportunistic behavior of most market players may lead them to continue producing conventional buildings (Akerlof, 1970). There is growing attention to the BEE market; however, it has expanded less rapidly than the world would like to see. The benefits to be secured from BEE are only vaguely understood and have not been widely pursued, particularly in the private sector of the building industry, which needs closer study.

This observation leads the author to study the market stakeholders to determine which of their fundamental concerns limit the BEE market. One fundamental reason is assumed to be their ignorance of the transaction costs involved, a problem that will be illuminated by the theoretical game model in Chapter Four. Game theory attempts to mathematically capture behavior in strategic situations, or games, in which an individual's success in making choices depends on the choices of others (Myerson, 1991). While initially developed to analyze competitions in which one individual does better at another's expense, game theory has been expanded to treat a wide class of interactions. Today, "game theory is a sort of umbrella or 'unified field' theory for the rational side of social science, where 'social' is interpreted broadly, to include human as well as non-human players (computers, animals, plants)" (Aumann, 1987). Many studies have applied game-theoretic models to simulate the decision-making process among business partners. This research has used game models to illustrate and explain the stakeholders' mind-sets and decisions about BEE.

A lack of concern and the failure to study the role of transaction costs also affects the potential economic effectiveness of policy implementations and markets. Even when research does mention transaction costs, it normally treats them as a whole and like other costs, with little detailed analysis of their specific, disaggregated effects. Moreover, research has not typically treated the interactions among stakeholders as involving such costs. So far, there has been little theoretical research into transaction costs (TC) using game models (GM) to develop a detailed analysis of the entire real estate development process (REDP) – research whose findings can then be tested by empirical study. This research does that and, in addition, brings its analysis and findings to the level of institutions to illuminate its policy implications.

Figure 3.1 illustrates the key issues of this research for which a critical review of the literature is provided to develop a clear understanding of how they relate to one another. The consolidated issues are summarized to help develop the research questions and propositions listed at the end of each section.

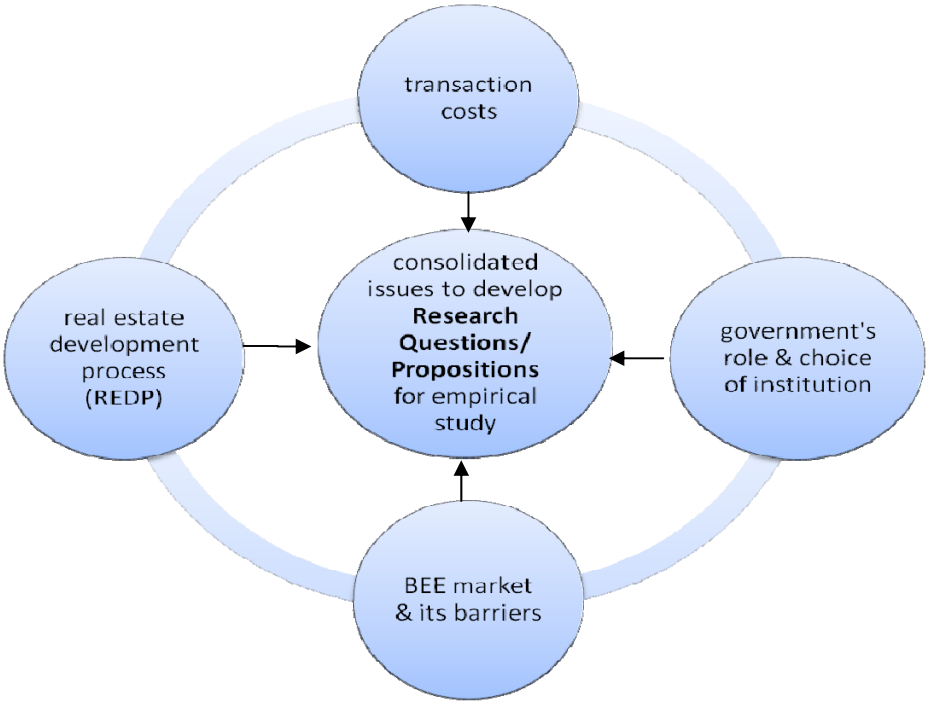

Figure 3.1 Five key research subjects and their interrelations

3.2 FRAMEWORK FOR REVIEWING BARRIERS TO BEE

There are major business challenges to promoting BEE effectively, even with the assistance of government. BEE largely depends on the willingness of the market to accept the construction of energy-efficient buildings. Advocacy and education are not enough; in addition, the market needs transparent information systems to disclose precise information about the products that go into such buildings. Advertisements might not help, since they would raise the price of energy-efficient technologies while leaving potential buyers uncertain about how to choose on the basis of this information in the mass media. This is one clear example of why the public might hesitate to adopt green technologies.

In-depth studies of particular forms of energy efficiency may be tremendously different given the character of the subject itself. For example, energy efficiency in buildings and industry are quite different given the processes of real estate development and of product manufacturing. Also, unlike industrial manufacturing, the construction industry cannot use mass production given that time, location, weather, and working teams play a great part, are specific and sometimes uncertain, and so would affect final costs. Therefore, it is important to take a close and focused look at the barriers to energy efficiency in the building sector.

3.2.1 Framework for Literature Review

A framework is developed in Figure 3.2 to look into the existing barriers in the BEE market from two perspectives: the market (real estate developers and end-users), and the government, with its institutional considerations. The overall plan is to identify the impediments to getting the BEE market working efficiently at a substantial size. When this happens, homeowners should have the information needed to make rational decisions about whether, how, and how much they want to pay for better energy performance. At the same time, real estate developers should know government policies well and be able to respond to consumer demands for energy- efficient buildings with consistent, efficient, and affordable solutions. Only with a good

understanding of the problems can there be an appropriate approach to developing valid resolutions to current problems. The literature review's framework of barriers to BEE, as shown in Figure 3.2, addresses the following specific areas:

- It develops an analytical framework to study barriers to increasing BEE;
- It reviews the characteristics of the building market with attention to BEE barriers;
- It identifies the barriers to BEE from the perspectives of government (G), market (D- developers), and end-users (E);
- It reviews and presents the barriers with clear examples of what concerns the stakeholders of real estate market have; and
- It develops propositions to be tested in the following chapters.

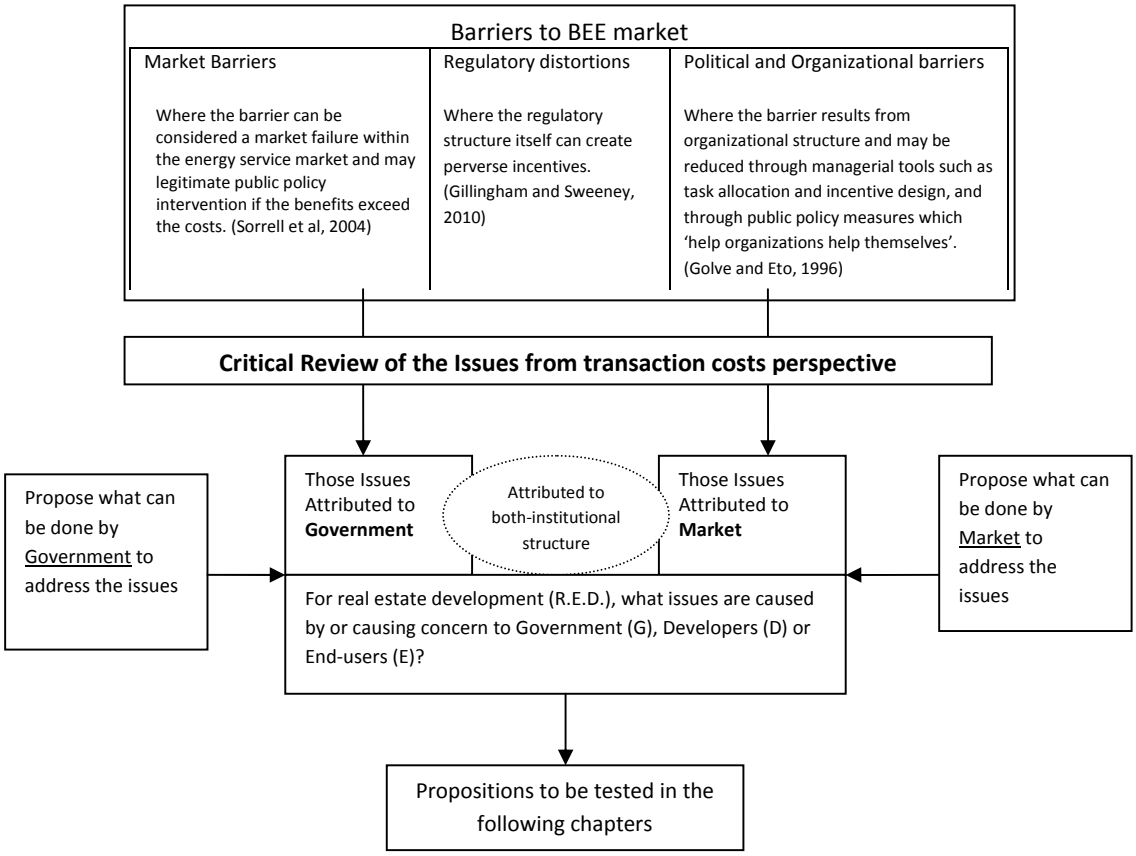

Figure 3.2 Framework for Reviewing the Barriers to BEE

3.2.2 Characteristics of the Building Market and Barriers to BEE

To understand the concerns of the market stakeholders regarding BEE investment, it is fundamental to start with a good understanding of the unique characteristics of the building market itself, which creates market barriers to BEE. The unique characteristics of the building market can be established from extant studies (Jaff and Stavins., 1994, Bell et al., 1996, Finkel, 1997, OECD, 2003) and are summarized in column one of Table 3.1. Those characteristics are illuminated by the examples in the table. For each of the unique characteristics, the author identifies the corresponding BEE market barriers, which are summarized in column 3 of Table 3.1.

With socioeconomic progress, more market stakeholders are getting involved in the building sector and are dedicated to their own business interests. Real estate developers intend to do no more than obey the basic requirements of the law and regulatory policies to minimize the increasing costs engendered by the extra work entailed by mandatory energy regulations. Contractors also want to avoid these extra tasks, because they require special expertise and specialized equipment that they do not typically possess. Manufacturers of BEE products want regulations to be still stricter to create greater demand. Building-design institutes will not be greatly influenced by the new policies but are apt to succumb to the demands of developers because of the nature of their relationship with them. However, these interests have not yet been fully expressed by the stakeholders themselves, because most of them are still learning about how to participate in policy making. These conflicting interests are the main source of the risks of and barriers to BEE development. Government could play an essential role by looking into the barriers and taking them into consideration in policy design.

Table 3.1: Characteristics of the building market and the corresponding barriers to BEE
(Adapted from Jaffe et al., 1999, Bell et al., 1996, Finkel, 1997, OECD, 2003, Sorrel et al., 2004)

Characteristics	Illustration	Remarks from BEE barriers' perspective
The longevity of life	Normally last for several decades, according to location, materials, construction methods, the way buildings are used and maintained, etc.	▪ The long-lived nature results in a low turnover rate of the building stock, thus affects the choice of policy instruments and market stakeholders. ▪ Technical innovation is difficult incorporated and updated into the existing building, thus causes concern to both developers and end-users to invest BEE without incentives.
High capital costs	Capital costs on buildings are apparently much higher than other commodities.	▪ To invest in BEE cause extra capital costs. ▪ Consumers and developers generally reject the efficiency option if their investment is not short paybacks.
Extended supply chain	The lifecycle of building is extended; generally divided into design & construction, use & refurbishment, demolition, and use of recycled materials.	▪ Different stakeholders in different stages have their own concerns and will decide to support or not BEE accordingly. ▪ For policy makers, the complexity of the supply chain provides many choices for intervention.
Split interests between owners and users	A considerable proportion of buildings, whether residential or commercial, are currently rented to individuals and firms.	▪ The owner/user discrepancy has caused "principal-agent" problems for improving the energy efficiency of rented buildings. Thus, there is a lack of incentive to make an extra investment for BEE. ▪ For policy makers, incentive schemes for promoting BEE in rented buildings may require a different approach than owner-occupied buildings.
Low level of standardisation	Most buildings are "custom-made' and designed to satisfy specific requirements of clients, e.g., specific conditions of the site, flexibility of the ground, climate of the area, surrounding environment and infrastructures.	▪ A building cannot undergo laboratory tests like other products to provide clear information on its quality. ▪ Potential buyers have difficulties to understand the level of performance of poorly standardized products like buildings than other products, especially the invisible performance like BEE. ▪ Potential buyers tend to lack information on the quality of buildings and BEE performance unless they conduct costly assessments, which causes great transaction costs.
Large heterogeneity in building design	The design of a certain building meets prescribed standards.	▪ Due to the large heterogeneity in building design, site-by-site inspections are usually required which effectively pushes up the administration cost either for the private sectors or the public sectors.
Slow to adapt new technologies	The construction industry is dominated by a large number of small-scale builders, who seldom assign resource/ staff for research & development, thus are slow to adapt to new technologies.	▪ The dominance of small-scale firms by the poorly standardized building process makes it difficult to exploit economies of scale. ▪ Government support for the dissemination of technical information among small-scale firms is necessary to promote BEE in the building sector.

3.2.3 Barriers to BEE Development

This section creates a typology of barriers to the promotion ofBEE. It explores their origins and suggests government measures that would overcome them. As most of this information is already discussed in the literature on market barriers, the contribution here lies in the systematic organization, synoptic view, and holistic treatment of them from the viewpoint of institutions (governmental and market). Current regulations and incentive schemes could thus be expanded and improved to lower these barriers. In that sense, the author intends to initiate a comprehensive review of institutional barriers, including market barriers and regulatory distortions, their origins, and potential ways to overcome them. Such an approach will facilitate the implementation of energy-efficiency improvements involving a wide range of ever-changing energy end-users and a wide array of consumer preferences.

Many studies and articles on policy measures discuss barriers to energy efficiency, either to illustrate the need for policy measures or to explain why policy tools are not as successful as expected (e.g., Deringer et al. 2004, Westling et al. 2003, Vine, 2005). Market failures prevent the consistent translation of specific energy-efficient investments into energy-savings benefits (Carbon Trust, 2005). The number of barriers is enormous – according to some estimates, they are higher in the building sector than in any other sectors (IPCC, 2007, Koeppel and Urge-Vorsatz, 2007). The barriers debate has been important for policy discussions about energy efficiency for two reasons. First, evidence of market failures provides a necessary condition for government intervention to improve overall social welfare, although this justification is not necessary for interventions aimed at the separable objective of improving social equity. Second, the analysis of particular market failures provides us with a much deeper understanding of how decisions to invest in energy efficiency are actually made in certain market sectors. This understanding is critical to a more comprehensive assessment of the efficacy of any particular public policy, which the author believes should be treated with specific reference to the particular market failures they seek to reduce or remove.

In this context, a barrier refers to a mechanism that inhibits decisions or behavior that appear to be both energy efficient and economically efficient. In particular, barriers are claimed to prevent investment in cost-effective energy-efficient technologies (Sorrell et al., 2004). The terms “barrier” and “market barrier” were introduced by researchers using engineering-economic models to study the technical and economic potential for energy efficiency. The observation that there was often little interest in investments with very high rates of return led researchers to postulate that such investments were inhibited by various barriers and that this justified public intervention. Harris and Carmen (1983), Koomey (1990), and Jaff and Stavins (1994) have developed a framework for analyzing market barriers that has been adopted for this research. A comprehensive framework for understanding such barriers (Table 3.2) can facilitate and organize the analysis of the reasons for divergences from economic optimality. Although general analyses of this type have been conducted for the energy sector as a whole (Blumstein et al. 1980, Fisher and Rothkopf, 1989), no similar analyses exist for a segment of the marketplace as narrow as this one.

Table 3.2 Barriers to BEE development

(Adapted from Harris and Carmen, 1983, Koomey, 1990, and Jaff and Stavins, 1994, Sorrel et al., 2004)

Type of Barriers		Nature of Barriers	Examples	G	D	E
Imperfect Competition	Natural monopoly	Economies of Scale	Electric/ heating utilities	×		
	Market power (Monopoly & Oligopoly)	Bargaining Power Interdependent Conduct	uniqueness of building location; few development firms in one area		×	×
	Anti competitive conduct	Collusion; predation	manipulation of permit process to the detriment of competitors	×		
Information uncertainty	Information costs	Transaction costs	high cost of customized audit; collecting product info; finding credible information sources	×	×	×
	Asymmetric information	Unequal bargaining	developer’s superior knowledge of building		×	×
	Misinformation	Misinformed exchange	belief: “no efficiency increase is possible”			×
	Lack of information	uninformed exchange	no knowledge of efficient technologies		×	×
Economic Non- Rationality	Bounded rationality and satisfying	using rules of thumb to reduce transaction costs; not maximizing profits	ignore costs that are less than 5% of rent; use a two year payback; seek acceptable profits		×	×
	Other non-rationality	cultural reasons for that affect business practice	preferring energy production to cost- cutting because it is more congruent with management culture		×	×
	Short-term visionary	a lot of small developers	small developers with short term visionary activities are unwillingness to invest in energy efficiency		×	×
	Behavioral constraints	Ignorance of opportunity and difficulty in changing lifestyle or behavior	Lack of awareness and low priority on energy efficiency; high subsidy on energy price		×	×

Risk Aversion	Risks	Resistance to change	avoid changes in suppliers and technologies; avoid construction delays; avoid new technologies		×	
Side Effects	Negative externalities from pollution& over consumption	Over consumption of power; costs imposed on non-subjects	Pollution and over consumption of energy		×	×
	Split incentives	utility costs not paid by purchaser or user of equipment	Landlord-tenant problem		×	×
Public Goods	R&D	Indivisibility, non-excludability, zero MCs	too little R&D performed	×	×	×
	Expertise and trainings	Indivisibility, non-excludability, zero MCs	too little training on efficient design, too little information dissemination	×	×	×
Cash Flow	Cash flow concerns	little attention paying on energy efficiency investments	windfall profits for most developers		×	×
	Cash flow constraints	lack of access to capital	Small business tenants on the edge; developer's reluctance to take on more debt.		×	×
Hidden cost and benefits	Risks, positive externality of the improved air and health condition by energy efficiency	Transaction costs, externality	transaction costs are high due to the fragmented structure of building sectors with many stakeholders; risk associated with the replacement technology; indirect benefits are neglected		×	×
Regulatory Distortions	Regulatory Bias	more utility profits for electricity production than for efficient use	utilities reluctant to install conservation, even when cheaper than new supply	×		
	Average cost pricing	price signals do not reflect cost, leading to inefficient usage	utility regulation	×		
	Building codes	obsolete contents inhibit innovation and efficiency; inconsistency inhibits achieving economies of scale	building codes contain requirements that interfere with efficient construction	×		
	Subsidies to Established Energy Technologies	Energy price does not reflect true cost	prices too low	×		
	Lack of management, supervision manpower and organizations	Regulatory distortions	Low level policy and law enforcement	×		
Political and Organizational barriers	Multi-institutional collaboration coordination	institutional interests	conflicts between policies and regulations from different agencies	×		
	Local government's resistance	unwillingness to change	local government mostly focus on developing GDP instead of energy conservation	×		
	governments Intervention into business activities	Distortion of market	governments intervene enterprise's micro decision making process	×	×	
	Less flexibility in local government	Unwilling to change or innovate	local governments have no incentive to innovate measures for BEE			
	Lack of long term energy conservation mechanism	Distortion of market	no long term regular mechanism for energy efficiency	×		
	Lack of credible third party agencies	Third party supervision	Less credible third party agencies for supervision, evaluation and examination	×		
	Slow pace of institutional reform	price signal do not reflect true cost	heating sector is still partly under central planned, pricing reform proceeds slowly	×	×	
	Social stability concern	price is lower than market price	afraid of social unrest in case of deepening heating reform	×		
	Incompatible between different measures	Lack of information exchange	lack of metering reform, which impedes the progress of pricing reform	×		
	Resistance from interest parties	unwillingness to change	indirect heating subsidies for government bodies, hard to change	×		
	Legal constrains	Affect the anticipated effectiveness of energy efficiency policies	Weak legal system and low level enforcement, no legal guarantee for the effective enforcement of new pricing scheme	×		
	Urban plan constrains	conflicted with building energy efficiency design	no active interaction between urban or community design with EE building design	×	×	
	Lack of investment culture	lack of consensus conscious or awareness of BEE	Low demand and supply, where the market needs more education	×	×	×
Noted: G- government; D- developer; E- end-users						

In essence, these barriers seem to be preventing this market's expansion from both the demand side and the supply side. First, on the demand side, the value of BEE is not reflected in the market price of buildings, largely because of information imperfection. There is an externality factor in BEE, and it cannot be easily and reliably measured and communicated to the market. Second, on the supply side, the BEE product is not easily standardized and measured, nor is there a simple and uniform process for mass customization. As a result, the barriers within each transaction make the deal too cumbersome and increase uncertainty. No research has shown any harm from BEE. However, the market seems to have an objection to accepting BEE on its own merits. More can be done by the government, as it has a unique ability to gather and publicize information, advocate BEE, and educate the public about it.

3.2.3. 1 Barriers relating to the market (developers and end-users)

This study focuses on two main market players involved with energy efficient buildings – the real estate developers and the end-users, who are at the two ends of the delivery of energy-efficient buildings. Table 3.2 illustrates that both the developers and the end-users happen to face similar types of barriers. It makes sense to believe that these two players are so interrelated in the market that any concerns that hinder them from investing in BEE will eventually keep the transaction from happening. Therefore, this part of the analysis focuses on both developers and end-users together to determine how their interactions affect their willingness to do business. Table 3.2 shows that the main barriers between the developers and the end-users fall mainly into the following categories – economic non-rationality, risk aversion, side effects, public goods, and cash flow.

- **Economic non-rationality**

Non-rationality refers to differences between the actual cognitive processes of real economic actors and assumptions about rational economic actors implicit in economic theory; it also refers to human beings' limited ability to collect and process information and their use of rules-of-thumb and satisfying behavior (Stern and Aronson, 1984,

Koomey, 1990). In this context, it includes bounded rationality, other non-rationality, short-term vision, and behavioral constraints. Basically, this category reflects the illusions and limited knowledge that both developers and end-users have about BEE investment. They either have an irrationally high expectation for the BEE investment return and/or payback period, or they are more interested in pursuing other short-term alternatives.

Behavioral and organizational characteristics of the end-users and the developers hinder the development of energy-efficiency technologies and practices. Small but easy opportunities for energy efficiency are often ignored, and changing behavior or lifestyles is very difficult (Shove, 2003, Chappells and Shove, 2005, Carbon Trust, 2005, Koeppel and Urge-Vorsatz, 2007). A lack of awareness and information about the opportunities and low costs of energy savings are a related problem. In developed countries, perhaps the most important impediment to improving energy efficiency is the small share and thus limited importance of energy expenditures of the disposable income of affluent households and businesses, which results in limited attention given to this issue among other choices for expenditure. This phenomenon can be described as bounded rationality according to Simon (1960), who argues that human beings make decisions and act only partly on a rational basis. In developing countries, energy expenditure represents a much larger share of disposable income, but subsidies often lower the energy price artificially, which does not provide an incentive for saving energy. Actually, energy subsidies are frequently considered to be one of the most important barriers for energy efficiency in developing countries (Alam et al., 1998, Koeppel and Urge-Vorsatz, 2007).

- **Risk aversion**

Convincing developers to replace familiar technologies and partnerships with new but more efficient ones is difficult, in part because it leads to more risk than society would otherwise face. The risks in this context include those due to economic fluctuations, policy instability, possible delay, and litigation. All these risks interfere with both the

developers' and the end-users' desire to make BEE investments and even halt BEE development to a certain extent, though in the aggregate, these risks should average out across the entire society and yield a positive economic return. However, for the individual economic actors, the developers and end-users, the risks may be greater than their theoretical share of the aggregate risk, leaving individual stakeholders reluctant to invest in BEE.

- **Side effects**

Side effects include negative externalities from pollution and the over-consumption of energy and split incentives. Traditional buildings that are not energy efficient consume more energy and release more carbon emissions during both the construction process and the operation period. These are the negative externalities, which need to be measured and whose costs need to be fairly apportioned to keep the end-users and developers from losing the motivation to further invest in BEE.

Split incentives appear very often in the economic literature in reference to the landlord-tenant problem. They are a major barrier in the buildings sector as the tenants who pay for energy are likely to be interested in reducing its use, but have no control over the system, whereas the building owners are not interested in improving energy efficiency. The developers are reluctant to invest unless someone is going to pay for it. Similarly, utilities have no direct interest in measures for reducing their clients' energy use. In the public sector, budget constraints are a major barrier preventing investments in energy efficiency (Carbon Trust, 2005, Urge-Vorsatz, Koeppel et al., 2007).

- **Public goods**

BEE is related to public goods issues in many ways. Greater energy efficiency would have a collective effect from which society as a whole would benefit. BEE would prevent society from consuming extra energy and releasing unnecessary pollution. In this sense, although the whole society may not participate in creating BEE, many would benefit as free riders. Therefore, in the absence of government intervention, BEE itself creates a

lack of interest in itself as a business initiative. The availability of information about BEE transactions is also a public good. The public requires a large flow of extra information to have full confidence in breaking its routine of investing in conventional building and investing in something new. Both the developers and the end-users need to have public and transparent information about technology. In this sense, government- or utility-sponsored research and development, professional training programs, and an information-dissemination channel are essential to BEE development.

- **Cash flow**

Cash-flow constraints are an important consideration for both the developers and the end-users. Purchasing more efficient equipment usually involves higher entry costs, which many consumers want to avoid and which low-income consumers cannot afford (Carbon Trust, 2005). In addition, higher capital costs raise the uncertainty and opportunity costs to the stakeholders, especially if the investment is financed by a mortgage or other loan. In addition to the higher capital costs, the energy-efficiency technology investment would normally require a longer payback period, which also increases the business risk for BEE investment to both parties. These are the important barriers to BEE development in developing countries and often cannot be dealt with internally. In developed countries, consumers often do not want to pay higher up-front costs because they either do not know or do not believe that investments in energy efficiency usually pay for themselves in a few years or even months.

- **Hidden costs and benefits**

In addition to higher up-front costs, there are hidden costs and benefits for the end-user that are not captured directly in financial flows. These include, for example, transaction costs associated with securing the energy efficient solution and risks associated with the replacement technology (Wrestling, 2003; Vine, 2005). Transaction costs are often high due to the fragmented structure of the building sector with its many small owners and agents. New technologies may not be compatible with existing sockets for example (Carbon Trust, 2005). Furthermore, the indirect benefits of improved energy efficiency,

such as reduced air pollution and improved health, are often ignored (Koeppel and Urge-Vorsatz, 2007).

- **Information uncertainty**

Lack of information about the possibilities and techniques for and potential of energy-efficient solutions is a major barrier, especially in developing countries, and is therefore mentioned as a separate barrier category here (Evander et al., 2004, Deringer et al., 2001).

3.2.3. 2 Barriers relating to the government

Table 3.2 shows that government, which plays an essential role as the moderator for BEE, creates barriers of its own. These fall mainly into the categories of regulatory distortions and organizational barriers.

- **Regulatory distortions**

The regulatory structure itself can create perverse incentives in the form of regulatory bias, average-cost pricing, building codes, and subsidies to established energy technologies. In China, the utility company has less motivation to implement conservation, as cutting electricity consumption reduces it profits. Energy in China is still underpriced due to its marginal costs and high government subsidies, and the distorted-price signal decreases the public's awareness and its caution about its energy consumption. The building codes are not updated in a timely fashion, which inhibits technology innovation and interferes with efficient construction; inconsistency also confuses the market and creates obstacles to the achievement of economies-of-scale for BEE.

- **Political and Organizational barriers**

Some barriers result from organizational structure and policy and may be reduced through managerial tools such as task-allocation, incentive-design, and other public measures (Golove and Eto, 1996, Sorrell et al., 2004). They often appear in developing

countries. In this case, there are many reasons behind the organizational barriers to BEE, including a lack of government involvement in promoting energy efficiency due to inadequate enforcement structures and institutions; inappropriate government intervention that distorts business activities; the inflexibility of local governments; an insufficient number of qualified personnel; the lack of a long-term energy conservation mechanism; a lack of credible third-party agencies; the slow pace of institutional reform; worries about social stability; policies or programs that are incompatible with one another; resistance from interested parties; legal constraints and urban-planning constraints; a weak investment culture; weak managerial supervision of manpower and organization; problems with multi-institutional collaboration and coordination; local governments' resistance to change; and corruption (Deringer et al., 2001). Basically, the government needs to play the role of a moderator who makes it convenient for the market to embrace BEE. The growth of the BEE market requires a politically friendly environment with the appropriate combination of government intervention and flexibility; it also needs a well-designed institutional structure to encourage investment and change the business culture. In this category, the government's role is mainly to set out a good foundation (the well-organized institution) and a clear domain (clear of constraints, but also some flexibility) for the BEE-market stakeholders.

3.2.3.3 Barriers relating to the government and the market (developers and end-users)

Table 3.2 shows both government and market representatives (developers and end-users) to be highly involved in the barriers raised by imperfect competition and information uncertainty.

Promoting BEE requires that government and all parties in the market work together. By and large, the government agencies concerned with energy efficiency end up confining themselves to providing publicity and information. The barrier in this case is that of the powerless energy-efficiency agency. At each stage, obstacles may arise whose removal requires multi-institutional collaboration and coordination. For example, public

procurement is complex and increasingly decentralized. Procurement officials work in an environment of conflicting policy objectives, extensive regulations, and a variety of pressures. The complexity tends to encourage officials to rely on past practices and avoid risks, which consequentially stifles innovation. Local governments tend to be interested in economic development, and they will not take energy targets seriously if achieving them contradicts their overall development plans. Local governments have less flexibility in policy design, which can lead to less innovation in the development of BEE. All of these problems create a less eager investment culture for the BEE market.

To determine the most needed policies to improve BEE in a particular society requires an in-depth understanding of the expectations of the market and government. Most policymakers regard energy efficiency principally as an environmental or social issue, rather than an economic one. Hence, policies are designed with inadequate consideration of the needs of market stakeholders and not pay enough attention to the necessity that businesses accept them. Government tends to pay more attention to the environmental consequences of energy consumption, and business enterprises may care more about their technical and financial ability to make changes, their potential economic benefits, and so forth. Detailed negotiation and greater understanding between government and the market stakeholders is needed to reach a win-win outcome.

3.2.3. 4 Institutional Consideration and TC Theoretical Framework

Neoclassical economics shows that a perfectly functioning market will yield an economically efficient outcome in equilibrium. However, no real-world markets meet all the assumed attributes of perfection. From the new institutional economics perspective, transaction costs are huge, and market failures, which often occur, inhibit exchange, production, and economic growth. The power of transaction costs under alternative institutional arrangements is also crucial to the workings of markets (Cheung, 1998; Coase, 1998; Benham and Benham, 1997; North, 1990, 1991). From a transaction cost economics perspective, researchers regard energy efficiency as a co-ordination and

incentive problem, rather than one of utility maximization, and they emphasize that policy intervention and different institutional structures may lower transaction costs and provide net social benefits (Golove and Eto, 1996; Levine et al., 1995). Behavioral economists add bias, errors, and decision heuristics into their consideration. Figure 3.3 gives a better picture of how different economic theories contribute to understanding the barriers to BEE. A better understanding of the nature and structure of barriers is necessary to design an incentive scheme that changes the market mechanisms for BEE investment. This study intends mainly to look at the barriers to the BEE market from the transaction costs economics perspective.

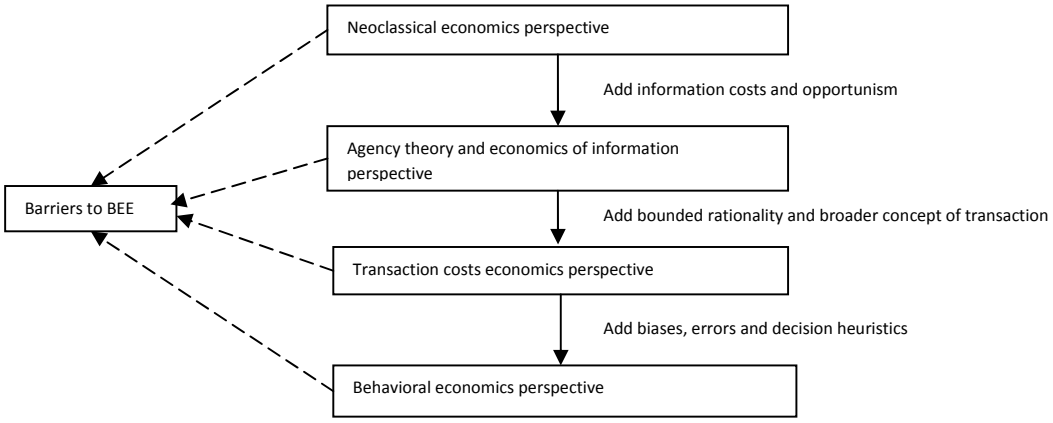

Figure 3.3 Economic theories on the barriers to BEE from different perspectives (Sorrell, 2004)

3.3 TRANSACTION STAGES IN THE REAL ESTATE DEVELOPMENT PROCESS

3.3.1 What is the "Transaction" in the BEE Project-Development Scenario?

> *North (1995, p. 68) concluded: "Transaction costs arise because of the costs of measuring the multiple valuable dimensions involved in exchange (broadly, information costs) and because of the costs of enforcing agreements. Information is not only costly but incomplete, and enforcement is not only costly but imperfect."*

The unit of analysis in situations that Coase describes is the transaction – the transaction between the regulatory agency and the private sector. The transaction in this study is

the process involving the developers and the end-users who take part in the BEE market. The purpose of choosing this transaction scenario for investigation is to examine the transaction costs incurred by the stakeholders upon choosing to invest in BEE, as compared to its conventional counterpart. As there is much literature supporting the value of BEE (Anthony and Rothkopf, 1989, Sutherland, 1991, Varone and Aebischer, 2000, Dennis, 2006, Qian and Chan, 2007a), this study was not undertaken to find more evidence for the necessity of BEE, or to provide further rationales for introducing incentive schemes. Instead, this study is intended to determine the concerns of the market stakeholders, concerns whose details have been ignored by current policies and research. The study is also intended to develop a theoretical framework by applying game theory and transaction costs economics to the study of business rationales and to find ways to improve the BEE business by putting more effective policies into place. It compares the extra efforts for BEE investments versus standard ones in terms of transaction costs to emphasize how transaction costs influence decisions about whether to invest in BEE. Hence, the transaction to be examined in this study is the real-estate development process, from the time the developer decides to invest in a BEE project until he delivers the BEE products to the market's end-users.

This study follows the well-established stages of real estate development in the *RIBA Outline Plan of Work* (RIBA 2007) to establish the transaction's stages and study the transaction costs involved. A copy of the adapted *RIBA Outline Plan of Work* is shown in Appendix 3.1. Table 3.3 is adapted from *RIBA Outline Plan of Work* and shows the developers' key concerns regarding BEE with reference to traditional buildings. The developers' key actions with reference to traditional buildings, as shown in column 3 (Tasks to be done) of Table 3.3, are developed from the *Architect's Job Book* (RIBA,

2008), *RIBA Chartered Practice Manual* (2010)[12], and *Architects Handbook of Practice Management* (Ostime and Stanford 2010).

According to the *Outline Plan of Work*, BEE development projects require the developers to do extra work. Professional practice manuals and the literature on green-building design and construction (Kats, 2003; Wang et al., 2005; Chan and Lau, 2005; Meng et al., 2006; Lee and Chan, 2007; Wang et al., 2008; Kibert, 2008; GBRC, 2010; RIBA, 2010) suggest that the possible extra work to be conducted by developers of BEE projects includes the following.

For the Briefing Stage

- Setting up extra organizational structures for briefings in relation to BEE
- Considering extra BEE-related market and policy requirements
- Appointing special architects and involving special stakeholders in relation to BEE
- Needing JV or co-developers for such special project
- Carrying out extra studies of market requirements and expectations for BEE (considering local community needs/supplies/competitiveness)
- Extra BEE planning, design, and cost, etc., as necessary to reach decisions
- Extra effort to identify potential users
- Studying the extra financial risk
- Considering the risk of extra legal liability for the BEE product
- More careful review of available information on BEE products

For the Sketch-Plans Stage

- Special-User Requirements studies
- Exploring special technical solutions
- Special concepts/designs that must secure government approval
- Designs leading to non-efficient uses of floor area
- Special cost studies for using new design features

For the Working-Drawings Stage

[12] RIBA (2010) RIBA Chartered Practice Manual 2010-2011, by the Royal Institute of Architects, England. (http://www.architecture.com/Files/RIBAProfessionalServices/MembershipAndMarketing/General/CharteredPracticeManual/CharteredPracticeManualMay2010.pdf)

- Financial negotiations for new design features (consideration of mortgage/loan/construction loan)
- Search for contractors with special expertise
- Reduced competition due to limited numbers of contractors available

For the Site-Operations Stage

- Extra effort to brief all project personnel on project requirements and procedures
- Special promotion strategy and materials for marketing and leasing
- Additional consideration of tenants for BEE products
- Extra requirements for testing and commissioning of service installations to obtain green labeling, etc.
- Special effort to prepare maintenance manual
- Extra fees for certification of green items

For the Feedback and Maintenance stage

- Special property skills requirement for property-management plans
- Special strategy and materials for overseeing marketing and leasing
- Keeping buildings running effectively and in good repair
- Setting up and managing ownership entity
- More special green items for property improvement
- Making it easy to sell or rent properties
- Additional guarantee certificates

Table 3.3: Outline Plan of Work in real estate development with DEVELOPER'S KEY CONCERNS (with reference to traditional buildings and BEE buildings)
(Adapted from the *RIBA Outline Plan of Work*)

Stage			Purpose of work and Decisions to be reached	Tasks to be done	People directly involved	Extra work with transaction costs incurred (in concern of BEE)
Briefing	A	Inception	To prepare general outline of requirements and plan future action.	Set up client organization for briefing. Consider requirements, appoint architect. **Developer's Key Actions:** **Identify opportunities (property/need/use/idea)** **Assemble co-developer** **Identify and review information** **Identify seed money** **Evaluate investment climate**	All client interests, architect.	1. Set up extra organization for briefing in relating with BEE. • new offices • new staffs 2. Consider extra BEE related market and policy requirements • market study in BEE • policy study in BEE 3. Appoint special architect and involve special stakeholders relating to BEE. 4. Need JV or Co-developer for such special project? 5. Carry out extra studies of market requirements and expectation on BEE (considering local community need/supply/competitiveness) 6. Extra BEE planning, design, and cost, etc., as necessary to reach decisions. 7. Extra effort to identify potential users 8. Study the extra financial risk 9. Consideration of extra legal liability risk of the BEE product 10. More careful review of available information on BEE products ANY oTHER tasks consideration purely related to meeting the HKBEAM/LEEDS requirement?
	B	Feasibility	To provide the client with an appraisal and recommendation in order that he may determine the form in which the project is to proceed, ensuring that it is feasible, functionally, technically and financially.	Carry out studies of user requirements, site conditions, planning, design, and cost, etc., as necessary to reach decisions. **Developer's Key Actions:** **Preliminary market analysis (community/supply/competitive)** **Assemble technical team** **Identify potential users** **Consider alternative site** **Preliminary financial plan** **Formal analysis (site/building/market/design/financial/appraisal)** **Investment threshold** **Legal issues** **Public participation** **Review available information** **Review objectives**	Clients' representatives, architects, engineers, and QS according to nature of project.	
Sketch Plans	C	Outline proposals	To determine general approach to layout, design and construction in order to obtain authoritative approval of the client on the outline proposals and accompanying report.	Develop the brief further. Carry out studies on user requirements, technical problems, planning, design and costs, as necessary to reach decisions. **Developer's Key Actions:** **Obtain control of the land/property** **Preliminary plans and sspecifications**	All client interests, architects, engineers, QS and specialists and all statutory and other approving authorities.	1. Special User Requirement study 2. Explore special technical solutions 3. Special concept/design that need negotiation with government for approval 4. Design leading to non-efficiency use of floor area

				Negotiation with government for approval		5. Special cost study for using new design features
	D	Scheme Design	To complete the brief and decide on particular proposals, including planning arrangement appearance, constructional method, outline specification, and cost, and to obtain all approvals.	Final development of the brief, full design of the project by architect, preliminary design by engineers, preparation cost plan and full explanatory report. Submission of proposals for all approvals.	Architects, QS, engineers and specialists, contractor (if appointed).	
	FREEZE SCHEME (Any change may incur very heavy abortive cost)					
Working Drawings	E	Detail Design	To obtain final decision on every matter related to design, specification, construction and cost.	Full design of every part and component of the building by collaboration of all concerned. Completer cost checking of designs. **Developer's Key Actions:** **Finalize plansand specifications** **Revise financial projections** **Financial negotiations (Mortgage/loan/construction loan)** **Tax consideration**	Architects, QS, engineers and specialists, contractor (if appointed).	1. Financial negotiations for new design feature (consideration of mortgage/Loan/construction loan) 2. Search for a list of contractor with special expertise 3. Limited no. of contractor available reduce competition
	F	Production Information	To prepare production Information and make final detailed decisions to carry out work.	Preparation of final production information i.e. drawings, schedules and specifications.	Architects, engineers and specialists, contractor (if appointed).	
	G	Bills of Quantities	To prepare and complete all information and arrangements for obtaining tender.	Preparation of Bill of Quantities and tender documents.	Architects, QS, contractor (if appointed).	
	H	Tender Action	*To select the most competitive tender and award the tender*	*Compile a list of tenders* *Issue tender documents* *Check and open tenders*	Architects, QS, engineers, contractor, clients.	
Site Operations	J	Project Planning	*To award the contract to the selected tender and brief all personnel involved of the project information and requirements*	*Notify acceptance of tender* *Check all contract document are in order* *Brief all project personnel of the project requirement and procedure for administer the project* *Check approvals and site condition to ensure the project can be carried out on site* **Developer's Key Actions:**	Contractor, sub-contractors.	1. Extra effort to brief all project personnel of the project requirement and procedure for administer the project 2. Special promotion strategy and materials for Marketing and Leasing

				Acquire property **Select construction Co** **Marketing and leasing** **Initial financing** **Assemble construction** **Management team** **Tennant involvement**		3. Additional consideration of tenant for BEE products 4. Extra requirement on Testing and Commissioning of service installations to obtain Green Labeling etc 5. Special effort to prepare maintenance manual 6. Extra fee for certificates involving Green items
	K	Operations on Site	*To ensure the project are constructed on site as approved plans and service installations are running properly*	*Sitting out the building on site* *Site meetings* *Supervision and site visits* *Financial monitoring of each construction stages* *Testing and Commissioning of service installations* *Prepare maintenance manual*	Architects, engineers, contractors, sub-contractors, QS, client.	
	L	Completion	*To handover building and prepare final account and certification*	*Check works ready for completion* *Hand-over inspection* *Rectify defects* *Final inspection and final certificate* **Developer's Key Actions:** **Inspection** **Certificate of occupancy** **Permission to sell/rent**	Architects, engineers, contractor, QS, client.	
Feedback & Maintenance	M	Feedback	To analyze the management, construction and performance of the project	Analysis of job records. Inspections of competed buildings. Studies of building in use. **Developer's Key Actions:** **Prepare property management plan** **Revise marketing plan** **Oversee marketing or Leasing**	Architects, engineers, QS, contractor, client.	1. Special property skill requirement for Property management plan 2. Special strategy and materials for Overseeing marketing or Leasing 3. To keep building running effectively and under good repair 4. Set up and manage ownership entity 5. More special green items to be taken care of for property improvement 6. Easy to sell or rent out property 7. Involve more guarantee certificates?
		Maintenance	To keep building running effectively and under good repair	**Developer's Key Actions:** Set up and Manage ownership entity Property improvement Property disposition Closing ownership entity	Developer, property manager, maintenance contractors/End-user	

3.3.2 Integrating transaction costs at different stages of the RED process for BEE

Each of the possible extra tasks may incur extra transaction costs which, based on the TC literature, can be categorized as research costs, information costs, analysis costs, decision costs, institutional-arrangement costs, evaluation costs, and so forth. These possible extra tasks and transaction costs, as suggested by the *Architect's Outline Plan of Work,* contribute toward building a framework as presented in column 5 (Extra work with transaction costs incurred in the context of BEE) in Table 3.3. They are summarized

to help develop the research questions and hypotheses for Chapter 5. The proper incentive schemes with reference to the transaction stages will then be developed to suit the business rationale of the stakeholders.

The transaction of concern in this study takes place between the developers and the end users, each of whom has to consider three things: the available incentive scheme and its foreseeable risk, their own capital situation, and their potential competitors and other available options, before they decide to carry out the transaction. The regulatory agency's primary purpose is to set up incentive schemes to attract the private sector to invest in BEE businesses, whereas the developer's primary purpose is to evaluate its own cost-benefit ratios under different incentive schemes and make an optimal decision for its own sake. As the incentive schemes are mostly on a voluntary basis, the private developers only agree to meet the conditions set forth by the government in exchange for a benefit that more than just covers its loss after an overall evaluation. The developers' private situations vary, so it is not useful to discuss the transaction costs arising from different situations case by case. However, it is rational and meaningful to study the barriers that cause extra concerns and corresponding transaction costs that the private sector developers face at various stages of the process during the real estate development process when they invest in BEE. Hence, this part of the study aims to address the following research questions:

- **What types of barriers exist in the BEE market?**
- **What are the market barriers to BEE for different market stakeholders during the real estate development process?**
- **What extra work arises from the barriers at different stages of the BEE development in real practice?**
- **What are the corresponding transaction costs specific to different stages of BEE-development in real practice?**

The underlying issues of these questions will be incorporated into the interview questions as presented in Chapter Five.

3.4 TRANSACTION COST ANALYSIS AND MEASUREMENT VARIABLES

3.4.1 Transaction Cost Analysis (TCA) Approach

> *"Without the concept of transaction costs, which is largely absent from current economic theory, it is my contention that it is impossible to understand the working of the economic system, to analyze many of its problems in a useful way, or to have a basis for determining policy." (Ronald Coase, 1988)*

> *"Any issue that arises as or can be reformulated as a contracting problem is usefully examined through the lens of transaction cost economizing." (Olive E. Williamson, 1997)*

Transaction costs, in Coase's (1937, 1961) original formulation, refer to "the cost of using the price mechanism" or "the cost of carrying out a transaction by means of an exchange on the open market". In Demsetz's study (1968), "Transaction cost may be defined as the cost of exchanging ownership titles". Gordon (1994) consolidated definition of transaction cost as the expense of organizing and participating in a market or implementing a government policy is the definition used in this study. A number of transaction-cost issues arise with respect to the development and implementation of BEE incentive schemes. Adapting this definition is in line with the work of other authors who treat transaction costs and administrative costs as essentially interchangeable terms (McCann et al., 2005).

> *Williamson (1996) emphasizes that, "after making the transaction the basic unit of analysis, the question that then needs to be resolved is what the principal dimensions are on which transactions differ. Furthermore, because order is accomplished through governance, similar efforts need to be made to identify the principal dimensions on which governance structures differ. A predictive theory of economic organization will, moreover, indicate which transactions will be organized how."*

In empirical studies, a direct measurement of transaction costs is simply the economic value of resources used in locating trading partners and executing transactions. Another common measurement of transaction costs is the difference between the prices paid by

the buyers and received by the sellers. Some studies focus more on secondary costs than on direct costs per se. For example, Williamsonian transaction cost economics is primarily interested in the secondary costs of negotiation and enforcement. Some are concerned with the cost of government regulations imposed on market entry and transactions, which either reduces the size of the market or eliminates the market altogether. In this study, the key TCA independent variables for measuring the preference of developers' for BEE investment with available incentive schemes are asset specificity (or specific investment), uncertainty (economic, market and policy unertainty), and frequency.

In this study, asset specificity refers to durable investments that are undertaken in support of particular transactions. These specific investments represent sunk costs that have a much lower value outside of these particular transactions (Williamson, 1985). Uncertainty refers to three aspects: economic uncertainty, market uncertainty and policy uncertainty. Frequency refers to how often the buyers make purchases in the market (Williamson, 1985).

A complete assessment in a single model of all the TCA independent variables – asset specificity, economic uncertainty, market uncertainty, policy uncertainty, and frequency – is important to fully examine the influence of each variable. Figure 3.4 is a TCA Model developed for this study to help understand developers' preferences for BEE investment with the consideration of transaction costs. Three measurement indicators for TC items in this study are money (M), time (T), and worry (W). Propositions will be developed, and a set of interviews will be conducted with developers, professionals, and academics to determine the importance of transaction costs. The results will be used to adjust the current incentive schemes to meet the needs of the market with better efficiency.

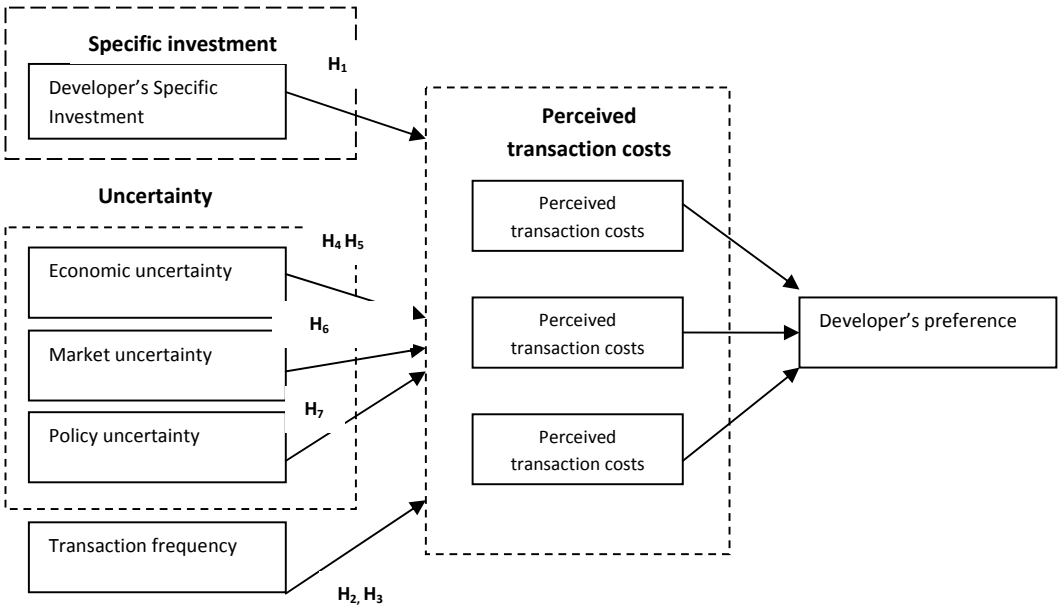

Figure 3.4: TCA model for real estate developers' preference on BEE investment (by the author)

> *Williamson (1985) argued that entrepreneurs (owners) in this class diversify risks to a fairly high degree to arrive at risk-neutral positioning. Where this assumption both facilitates and captures features of most transactions, non-compliance or exceptions can be handled separately.*

As Coase (1961) explains*, "In order to carry out a market transaction, it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on."* Thus, there is reason to look at market concerns in detail as well as at the effectiveness of BEE- incentive schemes for developers and end-users in the building industry. It is important to consider changing institutions, formal and informal rules and their enforcement arrangements, to the extent that these influence the nature of transactions and thus their costs.

3.4.2 Other transaction costs relating to incentive schemes

There will be transaction costs associated with developers implementing BEE-incentive schemes. BEE-incentive schemes require extra effort for the developers to understand and be prepared for their correct and efficient implementation. It is time-consuming to do this, which is why most incentive schemes are often ignored by the potential target groups during the early stages of public implementation.

Another consideration is that the costs of implementing BEE incentive schemes may decrease over time. According to McCann et al. (2005), the transaction costs associated with environmental policies may decrease over time as those involved learn by doing. The regulatory agency, the developers, and other market parties connected with BEE-investment will develop expertise and experience over time, which, when applied to new BEE-incentive schemes or projects, will decrease the time, the risks (worry), and/or the monetary costs of involvement. Rogers (1995) indicates that adoption and diffusion occur more rapidly with innovations that are easily understood and easily employed. Information about simple innovation is obtained more easily and effortlessly than that about complex innovations and is thus related to transaction costs (McCann et al., 2005). In addition, uncertainty affects the adoption rates of any incentive scheme, and obtaining information to reduce uncertainty is costly. Therefore, developers' transaction costs associated with BEE-investment under any incentive scheme may be underestimated if only the time and money spent collecting records and discussing the operation with government officials is measured.

Table 3.4: Taxonomy of the market barriers of BEE and the associated transaction costs considerations (Adapted from Sorrell et al., 2004)

Barriers	Common Claims	Remarks: BEE transaction cost considerations
Risk	▪ BEE investment represents a higher technical or financial risk than investing in conventional buildings. The business & market uncertainty encourages short time capital return.	▪ High asset specificity and higher risks than other forms of investment. ▪ Perceptions of risk may depart from that of a rational decision-maker in orthodox economic models and may bias against energy efficient investment.
Imperfect information	▪ Lack of information on BEE leads to high risks thus extra costs. It also leads to lemon market caused by inefficient products driving efficient products out of the market.	▪ Transaction costs associated with acquiring, understanding and applying information. Bounded rationality may apply. ▪ Transaction costs of information acquisition may be high due to quality and credibility.
Hidden costs	▪ BEE potential may be overestimated by failing to account for the reduction in utility associated with BEE technologies and other additional costs.	▪ The transaction costs associated with hidden items may overweigh the potential savings in energy costs.
Access to capital	▪ BEE investments may be avoided if market stakeholders have insufficient capital through internal funds, and has difficulty in raising additional funds. ▪ BEE investment could also be inhibited by internal capital budgeting procedures, investment appraisal rules and the short-term/instable incentives.	▪ Transaction costs associated with obtaining additional funding may be more significant for small cost-saving projects. ▪ The transaction costs of assessing investment opportunities may inhibit optimal decision-making. ▪ Severe costs may force managers to focus on strategic investments and overlook small cost saving opportunities.
Split incentives	▪ The cost and benefit of BEE investment is bear by different parties and difficult to appropriate the benefits of the investment.	▪ Transaction costs may inhibit shared saving contracts to overcome split incentive problems.
Bounded rationality	▪ Owing to constraints on time, attention, and the ability to process information, individuals do not make decisions in the manner assumed in perfect economic models. ▪ To avoid loss in time, money and risk, they tend to neglect BEE, even when given good information and appropriate incentives.	▪ Cost constraints may lead to the use of imprecise rules of thumb, which may neglect the small cost savings from energy efficiency improvement. ▪ Loss aversion and status quo bias may undervalue the benefits of energy cost saving. ▪ Risk aversion with respect to gains reinforces this inertia.

3.4.3 Transaction Cost Considerations of Developers in BEE projects

The BEE market barriers in Table 3.4 could be mapped to the taxonomy of market barriers used by Sorrell et al. (2004), and the barriers can be exemplified by claims commonly described in column 2 of Table 3.4. From the developers' point of view, they have to take into consideration all of the transaction costs identified in column 3 of Table 3.4. The transaction costs for developers that are due to the barriers to BEE are highlighted in the following.

3.4.3.1 Due to the BEE Market Barrier of Risk:

- BEE investments have high asset specificity and hence carry higher risks than other forms of investment.
- Individual and organizational perceptions of risk may lead to departures from rational decision-making that adopts orthodox economic models; this loss could create a bias against energy-efficient investment.

3.4.3.2 Due to the BEE Market Barrier of Imperfect Information:

- There will be transaction costs associated with acquiring, understanding, and applying information. Bounded rationality ensures that these will be significant, even when information is freely available.
- The transaction costs of information acquisition may be high as a consequence of poor presentation, the lack of credibility of the source, or the absence of interpersonal contacts.

3.4.3.3 Due to the BEE Market Barrier of Hidden Costs:

- The transaction costs associated with maintaining information systems, conducting energy audits, identifying opportunities, tendering and selecting suppliers, and seeking approval for capital expenditures may outweigh the potential savings in energy costs.

3.4.3.4 Due to the BEE Market Barrier of Access to Capital:

- There are transaction costs associated with obtaining additional funding from either internal or external sources, and these may be more significant for small, cost-saving projects.
- The transaction costs of transmitting and assessing information about investment opportunities may inhibit optimal decision making.
- Given severe constraints on time and attention, managers may focus on strategic investments and overlook small cost-saving opportunities.

3.4.3.5 Due to the BEE Market Barrier of Split incentives:

- Transaction costs inhibit the development of shared-savings contracts to overcome split-incentive problems.

3.5 A MARKET SITUATION THAT EMBRACES BEE

3.5.1 BEE as a part of Green Building

Environmentally, the building sector is responsible for high energy consumption, solid waste generation, global greenhouse gas emissions, external and internal pollution, environmental damage, and resource depletion (CICA, 2002; Melcher, 2007; Ortiz et al., 2009; Zimmermann et al., 2005). As the environmental impact of building activities becomes more apparent, a movement called green building is gaining momentum. Green, or sustainable building, is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition (US EPA Green Building, 2008). As energy consumption in the building sector is one of the main components of total energy consumption in most countries (Chan and Lau, 2005; OECD, 2003; Qian et al., 2006; Zhang, 2004), BEE becomes an important theme of GB, which brings together a vast array of practices and techniques to reduce the impact of buildings on energy consumption, the environment, and human health. As

BEE is relatively new, and the literature about its market is limited, it is important for this study to collect abundant information about the GB market and its embrace of BEE.

3.5.2 Business potential in GB market

Economic theories suggest that market structure and performance is determined by the ease of entry to and exit from a market (Baumol et al., 1982). Chiang et al. (2001) found that the institutional environment in Hong Kong led to the market concentration of the construction industry. Building contractors compete intensely over cost reductions rather than technology improvements. According to the Hong Kong Consumer Council's (HKCC, 1996) study, the local property development market was also highly concentrated. It is still true that only the large developers with superior financial resources can remain active in the sector. Under such market situations, the key market players have little incentive to venture into the new business of GB. Singapore, being a small city-state with a comparably sized building industry to that of Hong Kong, may have similar problems in entering the GB market. Ofori et al. (2000) opine that there are signs that environmental considerations will cause major changes in business practices involving construction in Singapore. Their study shows that knowledge of the ISO 14000 standards within the construction industry in Singapore is not widespread. Ofori and Ho (2004) reveal that architects in Singapore seem unable to translate their environmental awareness and knowledge into appropriate design choices. Ofori and Chan (1999) noted that environmentally conscious end-purchasers and building users are likely to emerge in Singapore in the near future. The external environment may compel developers to show their commitment to green building. Ofori and Ho (2004) suggest that society's attitudes toward the environmental impact can be translated into demand conditions, which would then influence corporate behavior, and educating the public could facilitate this change. Compared with conventional building, the entry barrier to the GB market is higher because of the new information, expertise, new technology, and financial risk involved. If there is asymmetric information about quality standards or mandatory requirements that are not imposed on the market, the opportunistic

behavior of most market players may make them continue to produce conventional buildings (Akerlof 1970).

There is a growing attention to the market for GB, though it has expanded less rapidly than the world would like to see. Energy-efficient buildings cost slightly more to build. Once completed, GB can save occupants 8-9% in operating costs, and these add up to significant savings over time. Over the past few years from 2005, the operating costs of GBs has reduced from 8.9% to 13.6% as building values have risen 10.9%, up from 7.5% (McGraw Hill's Construction, 2008). Kats and Capital E (2003) report that the financial benefits of green design run from $50 to $70 per square foot in a LEED building – more than ten times the additional cost associated with building green. A typical LEED-certified building uses 32% less electricity and reduces annual average CO_2 emissions by 350 metric tons (385 tons) (USGBC, 2007). The U.S. Green Building Council (2008) also reports the GB industry to be less affected by slowed markets compared with the traditional construction sector, as homebuyers take advantage of new government incentives. Recognizing these trends, builders, architects, and manufacturers may join the booming GB market, which will ultimately bring down prices for consumers (Fisher, 2006). However, the growing support for green development still comes only from federal agencies and visionary developers. The benefits from GB are only vaguely understood and have not widely penetrated the market, particularly in the private sector of the building industry. The above data and the benefits of GB may not apply to Asia, where the GB market needs close study. The following amplifies the justifications for focusing on the Hong Kong and Singapore markets for the survey analyzed later in this thesis.

3.5.3 Hong Kong and Singapore GB Market

In the past two decades, the construction industry in Asia has grown dramatically and is poised to continue to do so (Bon and Crosthwaite 2000; Raftery et al., 2004). The construction boom illuminates the simultaneous waste and good use of resources. Studying the fast-growing economic regions in Asia is thus important. To avoid, as far as

possible, being tainted by side issues, such as unreliable legal systems, rigid centrally planned economies, corruption, and unfair competition, Hong Kong and Singapore are deemed suitable choices to represent Asia for this study. They are both economically well-developed regions with free markets and well-educated professionals. They have comparable economic environments and are both international cities. The GDP per capita at current market prices in 2007 in Hong Kong and Singapore were U.S. $41,110 and U.S. $47,052 respectively (IMD World Competitiveness Yearbook, 2007). Construction as a share of total GDP has been in the range of 5-7% in Hong Kong and 4-6% in Singapore in recent years (Raftery et al., 2004). These two cities are both former British colonies with similar legal systems and have a predominantly Chinese culture with English as the common language. English is the language in which this study was conducted. The tropical climate of Singapore and the sub-tropical location of Hong Kong means that rain and sunshine are both plentiful. The rain catchment area is not big for either city given their small amounts of land, and Singapore has the added problem of being mostly flat. The efficient use of water is a big issue in both cities. This has some effect on GB design. Harnessing solar energy through solar cells, sun-shading devices, low-emissivity glass, energy-efficient air-conditioning systems, and building-space planning and orientation are common design considerations for GB in both cities. Singapore, situated at the Equator, may have fewer options for building orientation and sun-shading. Another issue is the threat of termites, so there is careful use of timber. There is also much research into paint, given how easily fungus grows, especially in Singapore, which began using fungus-resistant paint much earlier than did Hong Kong. Both cities have similar promotional strategies for GB, though Singapore's is more governmental, and it employs an assessment scheme (Green Mark Schemes) (BCA, 2005) more widely than does Hong Kong. Hong Kong relies more on voluntary effort, and there are several green groups, such as the Professional Green Building Council and the Green Council, promoting the voluntary use of GB. The HK-BEAM and other green-label programs are accepted assessment tools promulgated by voluntary bodies in the past

decade. In recent years, the Hong Kong government has begun to take an active part in driving GB initiatives (Chan, 2000; Chan and Lau, 2005).

3.5.4 Related Issues for Understanding the GB Market

3.5.4.1 Business reasons

There is much in the literature hinting that business incentives are important to making the GB market attractive (Church, 1994; Golove and Eto, 1996; Meyers, 1998; Melet, 1999; Jiang, 2007; Qian and Chan, 2008a). Lower operating costs and lower lifecycle costs are generally advocated as ways to cut down energy waste and reduce the burden of environmental problems (OECD, 2003; Qian et al., 2006). Many GB measures can be treated as investments, which will gain value over time (Prakash, 2002). GB investment will not only benefit the buyers and consumers, but also provide business opportunities for architects, developers, contractors, and almost all of the stakeholders in the building industry. New job opportunities arising from the increased marketability of new green products could help both the building and other industries to strengthen their market competitiveness as pioneers in transforming the market. Studies have also shown that enhanced daylight and reduced toxicity in indoor environments can increase employee productivity by up to 16%. Employees in buildings with healthy interiors have less absenteeism and tend to stay at their jobs longer (Atsusaka, 2003). However, even though GB makes commercial sense, Melet (1999) finds that many developers still do not commit to green design for other reasons. Ofori and Ho (2004) show that despite architects in Singapore indicating a high level of awareness of environmental impacts, they make environmental considerations a low priority when designing. These observations need to be verified for Asia to see if they still hold true given the recent emphasis on sustainability.

3.5.4.2 Obstacles to GB

Understanding the obstacles to GB development will help to find ways of promoting the GB market. The world's successful labeling programs, such as Energy Star and LEED,

provide helpful information and guidance on GB to the public. The literature shows that the rating systems and labeling programs are crucial to promoting GB (Lee and Yik, 2002, 2004; OECD, 2003; Ofori and Ho 2004; Qian and Chan, 2008c). However, not all governments do their jobs well in guiding the market with transparent and updated messages and policies. The existence of many unrecognized eco-labels for green products, as well as the lack of coordination or consistency in rating tools, does not serve the interests of the potential stakeholders in GB (Fisher and Rothkopf, 1989; Church, 1994; OECD, 2003; Vine et al., 2006; Qian and Chan, 2008c; Lee and Rajagopalan, 2008). The importance of the government's role in assisting energy efficiency and GB development is recognized (Fisher and Rothkopf, 1989; Sutherland, 1991, Golove and Eto, 1996, Varone and Aebischer, 2000, Ofori, 2006). However, there are complaints of insufficient fiscal incentives from the government to help offset the perceived higher initial costs of GB and green products, which decrease the attractiveness of GB. Different accounting methods, such as capital costs and operating costs, may also create stumbling blocks for those choosing between green and conventional buildings. Research also shows that it is inefficient to let the building market alone absorb the costs of promoting green or energy-efficient construction and products in the face of market barriers (Akerlof 1970; Golove and Eto, 1996; Qian et al., 2006; Dennis, 2006). Government plays an essential role in advocating this idea to the public. Education of and by construction professionals, awareness on the part of the public, and research and case studies about innovative GB are common issues brought up by both practitioners and academics (Church, 1994; Tan et al., 1999; Ofori and Ho, 2004; Hubbard, 2003; Qian et al., 2006; Raftery et al., 2006).

3.5.4.3 Favourable factors

Many in government, the business world, and academia would like to know how best to promote GB. A better understanding of the needs and expectations of the business stakeholders will bridge the gap between government and the market. Rising energy costs will increase the lifecycle cost, which increasingly makes GB preferable to conventional buildings (Lee and Yik, 2004). Government regulations and industry-rating

systems, such as LEED and Green Mark, play an important role in increasing the market for GB (Qian and Chan, 2008c). The superior performance of GB will attract the involvement of businesses wanting to establish their own brands and to consolidate their market shares. Education and public awareness of GB are also essential to opening new markets (Ofori and Ho, 2004). The demand from clients, the satisfaction of tenants, and the higher productivity of occupants due to GB are possible means to motivate the business stakeholders. Nowadays, more and more companies are aware of the worsening environment, and this often generates a sense of social responsibility. The greater availability of skills and technologies may lower the threshold price for GB investment and attract more businesses (Low and Chew, 1994; Ganeson, 1995; Prakash, 2002; Qian and Chan, 2008b). However, when these encouraging possibilities are viewed together with other business issues and with obstacles, even the stakeholders who are aware of its advantages may still not invest in GB (Ofori and Ho, 2004).

The above review summarizes the general perceptions and some unproven assumptions about GB markets around the world and in Hong Kong and Singapore. Regional climates and local social and economic conditions will create different needs for GB markets. The current state of research on GB markets calls for more focused study to understand the actual needs of a state or economic region with due attention to its local situations.

- **What are the major business reasons that drive the GB market?**
- **What are the major obstacles to GB?**
- **What are the major favorable factors that further the GB development?**

These questions from the surveys presented in Chapter Five are intended to gather information about the perceptions of GB by businesses and building designers in order to develop an overall picture of GB to compare with other aspects of this study.

3.6 GOVERNMENT'S ROLE AND CHOICE OF INSTITUTION

BEE still faces challenges in entering markets. BEE is often perceived as having higher initial design and construction costs than conventional building; energy-efficient mechanical and electrical systems may, for example, have higher initial capital costs than their counterparts in conventional buildings (OECD, 2003). It is argued that the extra costs will gradually be reduced as the new practices and technologies are further developed and more widely accepted by the market. However, the comparably higher initial costs and extra risks still cause stakeholders not to enter the new market voluntarily. In order to realize the desirable transformation to green, a push from the government is necessary to motivate the market (Atsusaka, 2003; Qian and Chan, 2007a, b; Varone and Aebischer, 2000).

Real estate developers are the dominant force in building markets, whereas the end-users largely affect the degree of BEE market penetration. As most incentive schemes are voluntary and market-based, the stakeholders involved are free to adopt or reject them. There are two major reasons that they are not attracted by or interested in most of the existing incentive schemes. First, the benefits from the government's schemes are not high enough, which means that the incentive itself is not sufficiently beneficial to make the potential investors buy in. Second, the extra effort, in terms of transaction costs, is too much, and they would rather give up the potential benefits to avoid the troublesome impediments and costs attached to change.

3.6.1 Government Supplements to the BEE Market

Significant improvements in BEE are achievable. Much building energy is wasted because of poor design, inadequate technology, and inappropriate behavior. Business needs to apply expertise and funding to develop and promote new approaches to energy efficiency, but significant change will not be achieved through the market alone. Business in the building industry needs supportive governmental policy and regulation to achieve dramatic improvements in energy efficiency.

Government's involvement in promoting GB is regarded as essential and effective (Varone and Aebischer, 2000; Atsusaka, 2003; Qian and Chan, 2007a), but there is disagreement about the extent and appropriateness of direct government involvement (Convery, 1998; Jaffe et al., 1999, Andersen and Sprenger, 2000; Varone and Aebischer, 2000; Chan and Yung, 2002; Su and Chen, 2005; Dennis, 2006). Energy analysts consider the deficiencies of BEE development, such as information asymmetry between end-users and real estate developers, the conflicting interests of landlords and tenants, risk distortion and the like, to lead to market failure. Thus, they see public intervention as essential to rectifying the situation (Golove and Eto, 1996; Varone and Aebischer, 2000). Dennis (2006) believes that the existence of market failures requires innovative policy intervention from government to achieve the optimal investment in energy efficiency. Even free market economists advocate the use of appropriate public actions to overcome obstacles where necessary (Anthony and Rothkopf, 1989; Sutherland, 1991). Most energy analysts and economists have also reached a consensus that government should play a role in BEE promotion (Atsusaka, 2003; Qian and Chan, 2007b; Varone and Aebischer, 2000). Many researchers now believe that government help is needed to build on market-based incentives, and they call for forward-looking energy policies to address the problems of both market and non-market failures in BEE development (Dennis, 2006).

It is still debatable how the government can supplement the market for GB promotion. Markets could evolve spontaneously and operate well without the interference of government (Fafchamps, 2002; Rosler, 1989). Regulations and rules may ensure a minimum standard of quality but increase transaction costs. A market could be maintained by the institutional framework involving volunteering individuals or organizations, such as professional institutes, or through self-regulation with informal rules to maintain low barriers to entry. Many studies have explored the best way for the government to increase the market share of GB (Varone and Aebischer, 2000; Atsusaka, 2003; Qian and Chan, 2007a).

3.6.2 Government's Roles, Incentive Schemes, and the Private Sector

A good understanding of incentive schemes starts from a review of the literature on governments' role in BEE promotion. The items that authors of previous studies have identified as the practices that governments should undertake are summarized in Figure 3.5 (Anthony and Rothkopf, 1989 Sutherland, 1991, Golove and Eto, 1996, Varone and Aebischer, 2000, Dennis, 2006, Qian and Chan, 2007a, 2008a,c). The figure provides an overall picture of incentive schemes; the government's functional role in BEE promotion, and the elements involved in each of the roles government plays or could play. This research addresses the issues embedded in the market by exploring the solutions offered by government incentives.

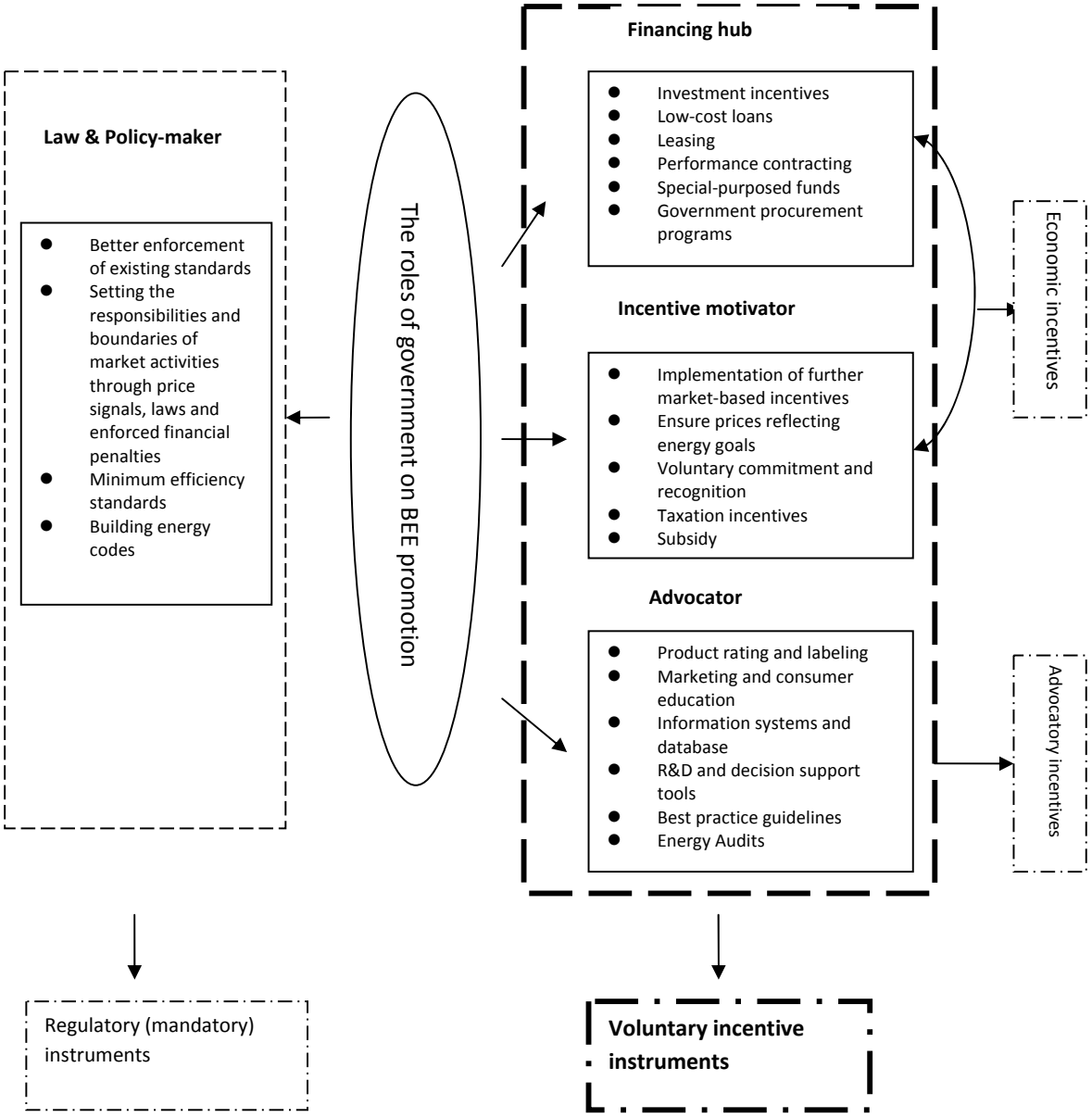

Fig.3.5 Government's role in BEE promotion

(Adapted from Qian and Chan, 2007a, b, 2008b)

Successful experiences from developed industries show that BEE-incentive schemes should be co-designed by government and the private sector to avoid creating or exacerbating BEE market barriers to implementation (Meyers, 1998, Vine et al., 2006). After these incentive schemes are established, the private sector, namely market stakeholders, will send out market signals as feedback, which governments could then

use in adjusting their incentive policies for BEE promotion. With the full cycle of renegotiation and redesign of the policy instruments (i.e., the incentive schemes), the collaboration between government and the private sector would operate to help the government promote BEE in a cost-effective way. Figure 3.6 below shows the process of the co-design and renegotiation of incentive instruments by government and the private sector.

From policy implementation and the ex-ante review and assessment cycle, it is noted that most policy is based on real market experiences. This may cost time and money for both the policy maker and the BEE investors. The situation will not only decrease the effectiveness of the incentive scheme itself, but also cause the stakeholder to lose faith in future government BEE incentive schemes. Therefore, before designing or implementing incentive schemes, a better understanding of the market stakeholders' consideration of transaction costs is necessary.

In this part of the study, the analysis of the survey and interview finding in the context of the literature review aims to address the following research questions:

- **How can institutions, in the Hong Kong case, help to overcome BEE barriers to different market stakeholders in terms of transaction costs?**
- **What roles can government play through institutional rules in promoting the BEE market?**

To answer these research questions, it is necessary first to investigate the critical underlying issues, such as what kinds of market systems, what degrees of economic development, and what kinds of political environments might affect the nature of incentive schemes.

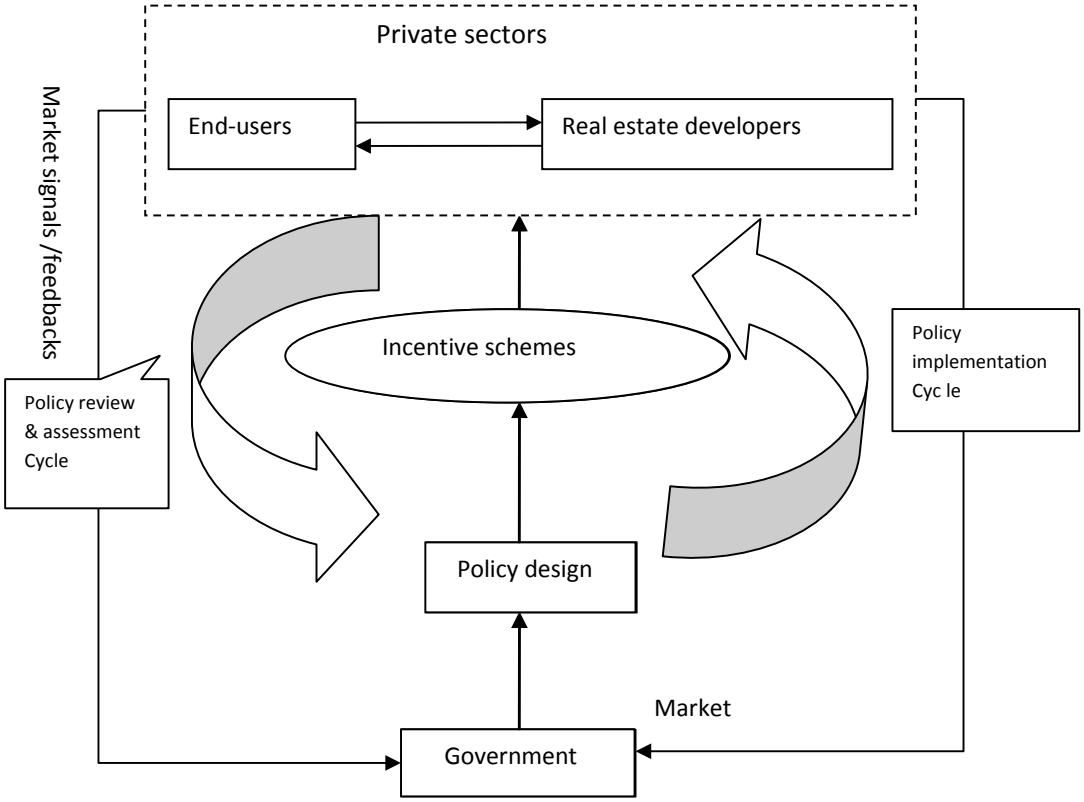

Figure 3.6 Process of Incentive Instruments co-designed by government and private sector (Qian and Chan, 2008a)

CHAPTER FOUR: MODELING THE BEE MARKET

Overview

In the previous chapters, theories of transaction cost economics (TCE) have been applied to help explain and characterize the barriers of BEE that prohibit the market stakeholders- the developers, the end-users, from actively engaging in the BEE market. It concludes that it is impossible for the stakeholder to tap all the energy efficiency potential alone within the building sector, given that the BEE carries the character of partial public goods and the complexity of BEE problems involving so many different stakeholders with conflict interests.

In view of the interdependent transaction decisions in the real estate market, this chapter further proposes a game model methodology to simulate the interactions "between the developers scenario" and "between the developers and end-users scenario" respectively in the BEE market, and attempt to theoretically capture behaviors in strategic situations in a mathematic approach. By applying TCE to the game model, the transaction costs impact to the equilibrium of decision-making of different stakeholders will be investigated, and the policy implication for promoting BEE will be drawn, in theory, from the perspective of reducing transaction costs. Our goal is to contribute some new ideas to the current studies on BEE, to provide a framework for the application of TCE to theoretical study of BEE market, and to analyze policy prescriptions for promoting the development of BEE market in a convincing way.

This chapter begins with a brief review of the literatures on game theory and its implications in BEE studies, followed by the game model between the developers in BEE markets, and the game model between the developers and the end-users. Within each section, the scenarios are discussed and compared with and without transaction costs. Finally, specific attentions are paid to the attributes of the transaction costs and its impacts on the equilibrium decisions to stakeholders. Policy implications will be drawn accordingly.

4.1 LITERATURE REVIEW

Game theory deals with how individuals behave in interdependent decision situations, and has a wide range of implications in fields such as economics, social science, philosophy and management. 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 interactions among the stakeholders.

Game theory is a branch of applied mathematics that is used in the social sciences, most notably in economics as well as in biology, engineering, political science, international relations, computer science, social psychology, philosophy and management [13]. Researchers in the building field also apply game theory to explain and analyze a wide array of phenomenon in the field of energy efficiency of the real estate market and BEE development. Most game models were formulated from the perspective of market stakeholders, either between the government and the developers, or between the developers and the end-users. Shang, Du (2005) proposed a static game model with perfect information between local government and the developers, indicating that changes in the mechanism of land transaction had an important and direct impact on BEE development. Zhang (2004) establishes a three-stage pricing model for real estate, stating that the land price is firstly decided by the game between the governments and developers then the developers compete to maximize their profits with a differentiated product strategy in the real estate development process, finally the market price of the real estate is decided by the game between developers and end-users within complete information. Zhou (2006) formulates a dynamic repetitive game model between the developers to investigate the strategies regarding the quality of real estate. It points out

[13] http://en.wikipedia.org/wiki/Game_theory

that whether the developer would take a differentiated product competition strategy or a price competition strategy depends on the market structure, the number of game stages and the availability of relevant information. Some game models are formulated to analyze factors key to BEE development, aiming to make policies more targeted. Sun et al (2009) established a two-stage Stackelberg game model between government and other investors during the process of incremental investment and financing in BEE market, concluded that investment and policies from government at the initial stage of BEE development would affect the efficiency of total investment of the market. Some researchers also observed the effects from limited rationality and information asymmetry in BEE market. Zhou (2006) established an evolutionary game model between the developers to analyze the formation and evolution of reputation, by interpreting the development of BEE market structure based on Reputation Hypothesis.

Modeling 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. Game theory has been widely used as a technology for framing various constraints on behavior by well-informed agents operating in institutional straightjackets since firstly invented by Neumann and Morgenstern (1944). 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, previous studies with respect to BEE always regard the developers and the end-users as a whole, and try to tap the energy efficiency potential from the government's perspective, with less attention to the market stakeholders' perception. In the real world, however, 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, demand forecast, development strategy of the

counterpart, would hugely affect each developer's decisions upon BEE development. Therefore, the author is motivated to model the BEE market from the stakeholder's perspective, taking account of the transaction costs involved.

Secondly, current attention mostly concentrate on the barriers of BEE from cost-benefit analyses based on price theory of classic economics, which agrees that higher construction cost and market price of BEE are the key factors preventing BEE development. However, transaction costs, which arise from information asymmetry, risk, uncertainty about BEE performance and limited rationality of stakeholders in BEE market, etc, are either neglected in the research hypothesis, or not adequately reflected in the modeling work.

Thirdly, 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. Despite some studies have considered the transaction costs when modeling the BEE market, most take the transaction costs involved in BEE market similar to other common type of costs, i.e., extra physical costs needed compared to conventional buildings. 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.

4.2 GAME MODEL BETWEEN THE DEVELOPERS

Competition between the developers is an important factor 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. By modeling the game between developers over BEE investment, we will investigate mechanism of competition between developers, look into the transaction costs impacts on game equilibrium, and draw policy implication on how to increase the willingness to supply from the developers by reducing the market transaction costs.

4.2.1 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; UNDP, 2009). 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. Thus, it is reasonable to get government involved in promoting BEE practice, for example, by subsidizing the developers to lower the costs for developing BEE, as well as granting other favorable tax incentives.

Theoretically, it is proved that BEE is beneficial to most of the market stakeholders from the cost benefit analysis perspective. In real life, however, specific cost and benefit for each developer is unknown, and cannot be accurately estimated. 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. This argument is valid due to the following reasons: (1) In most cases, end-users are usually more concerned about issues such as the location, qualities, house layout, facilities, traffic conditions and the surroundings, with less awareness of its energy efficiency performance. (2) Since BEE is only one of the features of real estate product, it is difficult to separate the extra value of BEE from the real estate product accurately and evaluate whether the extra expenditure on BEE is worthy or not. (3) Even if the consumers are fully aware of the cost and energy efficiency performance of BEE, the actual benefit, in terms of energy expenditure savings, is still uncertain. The reason is that the overall benefit also depends on other mixed factors such as energy price, consumer behaviors and lifestyles, which can only be verified through the whole life circle of the building.

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.

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.

4.2.2 Transaction costs in the game between the developers

As discussed in Chapter Three, 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. 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 (Han, 2010).

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. Further 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 decision-making of BEE investment to both parties- developers and end-users. Later on, the findings would be helpful to give policy implications on how incentives with government intervention to market should be designed to most effectively offset the negative concerns to BEE.

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, which aim to improve the performance of energy efficiency, are one of the determinant factors to distinguish the developers from each other in the market. Besides, for a typical building project, as discussed in the previous chapter, 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 each other, in line with the differences of awareness on BEE, scale, market share, position, as well as development strategy of different developers.

To keep things simple and focus on the BEE market, it is always reasonable to assume that, with the diffusion of information and know-how to develop BEE, costs for developing 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

author will explicitly introduce transaction costs as a whole in a systemic game model to explore the impacts on the stakeholders in the BEE market.

4.2.3 Presenting the game model between the developers

We present a game model of 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, 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 $I = \{1,2\}$ be the set of players (the developers) involved in the game model for BEE development, let $\mathrm{R_i}$ 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:

$$Max\ R_i = p * q_i - C_i(q_i)$$
$$\text{s.t.} q_i = f_i(x_{1,} x_{2,} \dots \dots x_{n,})$$

where $\mathbf{R_i}$ is the profit of developing BEE for Developer $\mathbf{i}$, $\mathbf{q_i}$ is the quantity of BEE by Developer $\mathbf{i}$, $\mathbf{x_i}$ (i=1,…,n) is the quantities of inputs such as land, labor, capital, construction and raw materials, $\mathbf{f_i}$ is the production function for Developer $\mathbf{i}$,, $\mathbf{C_i(q_i)}$ is the cost per unit to develop BEE for Developer $\mathbf{i}$, and $\mathbf{p}$ 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, $\mathbf{C_i(q_i)}$ can be assumed in a linear function form as:

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

where $\mathbf{c_k}$ is the cost per unit of input $\mathbf{k}$ for developing BEE, which are determined empirically in the BEE market.

4.2.3.1 Game model between the developers without transaction costs

One hypothesis is set up as follow:

Hypothesis H1 (GM)
Quantity of BEE developed in the monopoly market is smaller than that in a perfect market with two developers, but the monopoly profit is bigger than profits of the two developers combined in a competitive market.

Transaction costs are accepted as the most fundamental feature of the real world in modern economics, as contended by Coase. 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 $\mathrm{P(Q)}$ denote the price function,

$$\boldsymbol{p = P(Q)}$$
$$\boldsymbol{s.t. Q = q_1 + q_2}$$

where$\mathrm{Q}$ 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:

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

Hence, take the derivative of $\mathrm{R_i}$ with respect to $\mathrm{q_i}$, and set it to zero for maximization:

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

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

$$\boldsymbol{q_1^* = f_1(q_2),\ q_2^* = f_2(q_1)}$$

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

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:

$$\boldsymbol{p = P(Q) = a - (q_1 + q_2)}$$

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

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

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

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

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

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

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

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

Solving the two equations simultaneously, we have the Nash equilibriums $(\mathrm{q}_1^*, \mathrm{q}_2^*)$ for Developer 1 and 2:

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

Then the optimum profit for each developer is:

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

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:

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

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

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

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:

$$Q^* = \frac{1}{2}(a - c - c_0) < q_1^* + q_2^* = \frac{2}{3}(a - c - c_0)$$
$$R^* = \frac{1}{4}(a - c - c_0)^2 > R_1^* + R_2^* = \frac{2}{9}(a - c - c_0)^2$$

Conclusions and Policy implications:

- 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 two aspects, one by providing more BEE products, the other by increasing the total consumer surpluses in market.

4.2.3.2 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:

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

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 process[14]. 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 increase 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:

$$\boldsymbol{p = P(Q) = a - (q_1 + q_2)}$$

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 $\sum_{k=1}^{n} c_k^1 = \sum_{k=1}^{n} c_k^2 = c$, then cost function for developer i is:

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

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

[14] 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 don't.

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

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, the smaller quantity of BEE it would develop.

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:$\mathrm{TC_i} = \mathrm{k_i} * \mathrm{q_i}$. 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:

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

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

$$q_1^{***} + q_2^{***} \leq q_1^* + q_2^*$$
$$q_1^{***} > q_1^*, \text{ if } k_1 < \frac{1}{2}k_2.$$
$$q_1^{***} \leq q_1^*, \text{ if } k_1 \geq \frac{1}{2}k_2.$$
$$q_2^{***} > q_2^*, \text{ if } k_2 < \frac{1}{2}k_1.$$
$$q_2^{***} \leq q_2^*, \text{ if } k_2 \geq \frac{1}{2}k_1.$$

Conclusions and Policy implications:

- 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 government interventions, by all means to reduce transaction costs in the BEE market, 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.

4.2.3.3 Further discussions about transaction costs

In the previous parts, we frame a game model between the developers and discuss the general impacts from transaction costs. The author so far, regards all the transaction costs as a whole and views it the same as the necessary input costs such as finance, technology, labor and materials for developing BEE. With respect to transaction costs, the author further assumes the specific function forms and analyzes the impacts in the game models with/without transaction costs, concluding that they constitute an important factor in the decision making process of developers.

However, it is widely known that the nature and characteristic of transaction costs are different from those of common costs, and some contend that transaction costs are ambiguous and most likely exaggerated for decision makers due to the difficulty of measurement. Besides, transaction costs also vary a lot in different institutions, cultures and societies, which make the analyses much more cumbersome. This inspires the author to further improve the game model between developers to find out how the transaction costs prohibit developers from investing in BEE, when there is a lack of precise measurement of such costs.

As the concept of TCE shows, it is not only the transaction costs level in the context of the BEE market that is of interest in cost analyses, but also their determinants. It is important to explore how the most weighed attributes of transaction costs affect the stakeholders' decision-making during the market transaction. In this part, the author further demonstrates the impacts on developers from transaction costs, by improving the game model from the perspectives of uncertainties and risks, showing how the transaction costs are involved in the decision making process of developers.

4.2.3.3.1 Transaction costs from the perspective of uncertainties

Two hypotheses are set up as follows:

Hypothesis H2 (GM)
In the Bayesian Cournot game model between developers with incomplete information, Developer 1, who develops genuine BEE products, will develop a smaller quantity of BEE, comparing with that would be developed in a complete information market, in light of transaction costs that may be incurred by uncertainties.
Hypothesis H3 (GM):
In the Bayesian Cournot game model between developers with incomplete information, the total supply of genuine BEE products in market would decrease, if the proportion of credible developers (who develop genuine BEE products) in market decrease, implying that the unfair competition situation worsens BEE market development.

Uncertainties due to information asymmetry are the fundamental aspects of transaction costs, which will be confirmed from interview data of this thesis. In the supply side, the developer has to search detailed information about strategies of his opponents before he decides to invest in BEE. The searching process may incur high transaction costs that even prevent him from entering the market. The primary reason is that the degree of compliance of BEE code cannot be perfectly observed from the public, and some developers may exaggerate the energy efficiency performance. The extreme case is to sell the conventional building product at the price of BEE, which would fill the BEE market with a lot of fake and low-quality non-BEE products. As practical evidences show, the inability to distinguish the BEE from the non-BEEs and the constant doubt from the

public further undermines the attractiveness of BEE to stakeholders and eventually leads to a “Lemon market”. Based on the game models between the developers above, we consider an improved model to look into the impacts from transaction costs from the perspective of uncertainties.

Followed the Bayesian game theory and John C. Harsanyi’s framework, we extend the model into a Bayesian Cournot game model under incomplete information. Assume that Developer 1 is of a certain type, which actually develops and sells genuine BEE products in market. Developer 2 may be one of two types, he may develop and sell the genuine BEE products as well, or he may develop conventional building products but advocate them as BEE products. The information possessed by Developer 2 is perfect: he knows preference, choices and all the costs information about Developer 1, while Developer 1 only adopts an initial belief about whether Developer 2 develops genuine BEE products or not. Without losing generality, we assume that Developer 2 starts with the two-point probability distribution, that is, the probability is μ if it develops genuine BEE products, and $1-\mu$ if it develops only conventional building products but sells them as BEE products, $0 \leq \mu \leq 1$, and these are common knowledge. Noted here the probability could also be interpreted as the proportion of credible developers which develop genuine BEE products in the market. The lower the probability is, the higher the risks are for developers to invest in BEE, since they would face a lot of unfair competition in the market.

From the perspective of TCE, higher uncertainties and risks would increase the transaction costs for information searching, risk aversion, etc., to the developers in the BEE market. On the other hand, although it is hard to accurately estimate the transaction costs incurred in the process of BEE development, these costs are indeed taken into consideration by the developers through other ways. In this scenario, the probability μ by Developer 1 provides a substitute proxy to estimate the transaction costs occurred. For example, if there are a lot of unfair competitions, fake BEE products in the market, implying a low probability of credible competitors, the developer then

has to compete in an unfair market environment and the expected transaction costs are definitely higher. Here, we extend the Cournot game model outlined above to handle the scenario with uncertainties, looking into the impacts from transaction costs in a different perspective.

Noteworthy that the strategy of each developer will change accordingly in the scenario considered with uncertainties. For Developer 1, the probability that his opponent develops genuine BEE products is a random variable μ drawn from a two-point probability distribution function, thus, best response from Developer 1 would be made by maximizing his expected profits from developing BEE, given his beliefs in Developer 2. For Developer 2, he has perfect information about Developer 1, and is fully informed of the strategies of Developer 1, therefore, best response from Developer 2 would be made by maximizing his profits, given strategies of Developer 1.

For simplicity, we assume the price function of the total quantity of BEE developed is linear, given by:

$$\boldsymbol{p = P(Q) = a - (q_1 + q_2)}$$

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. The cost function for Developer 1 is as follows:

$$\boldsymbol{C_1(q_1) = c_0 * q_1 + c * q_1 + k_1 * q_1}$$

For Developer 2, if it develops genuine BEE products, the cost function is:

$$\boldsymbol{C_2(q_2) = c_0 * q_2 + c * q_2 + k_2 * q_2}$$

If Developer 2 decides to develop fake BEE products, that is, the conventional building products, then the cost function is:

$$\boldsymbol{C_2(q_2) = c_0 * q_2}$$

wherec_0 is the cost per unit to develop a conventional building, c is the extra cost per unit to develop BEE, k_i is the transaction cost per unit to develop BEE, q_i is the quantity of BEE developed by Developer $\mathrm{i}.\mathrm{TC}_\mathrm{i} = \mathrm{k}_\mathrm{i} * \mathrm{q}_\mathrm{i}$ represents transaction costs involved for

Developer i. We assume that information about costs is common knowledge for both developers.

Letq_1^{**} denote the equilibrium quantity of the genuine BEE products developed by Developer 1, q_{2T}^{**} denotes the equilibrium quantity of genuine BEE products by Developer 2, and q_{2F}^{**} denotes the equilibrium quantity of fake BEE products by Developer 2.

Proposition 4. *In the Bayesian Cournot game model between developers with incomplete information, there are two Bayesian Nash equilibrium quantities of BEE developed. When Developer 1 and 2 both develop genuine BEE products, the equilibrium is given by:*

$$(\boldsymbol{q_1^{**}, q_{2T}^{**}}) = \begin{Bmatrix} \frac{1}{3}\boldsymbol{a} - \frac{1}{3}\boldsymbol{c_0} - \frac{2}{3}\boldsymbol{c} - \frac{2}{3}\boldsymbol{k_1} + \frac{1}{3}\boldsymbol{\mu} * \boldsymbol{c} + \frac{1}{3}\boldsymbol{\mu} * \boldsymbol{k_2}, \\ \frac{1}{3}\boldsymbol{a} - \frac{1}{3}\boldsymbol{c_0} - \frac{1}{6}\boldsymbol{c} - \frac{1}{2}\boldsymbol{k_2} + \frac{1}{3}\boldsymbol{k_1} - \frac{1}{6}\boldsymbol{\mu} * \boldsymbol{c} - \frac{1}{6}\boldsymbol{\mu} * \boldsymbol{k_2} \end{Bmatrix}$$

When only Developer 1 develops genuine BEE, while Developer 2 decides to develop fake BEE products, the equilibrium is given by:

$$(\boldsymbol{q_1^{**}, q_{2F}^{**}}) = \begin{Bmatrix} \frac{1}{3}\boldsymbol{a} - \frac{1}{3}\boldsymbol{c_0} - \frac{2}{3}\boldsymbol{c} - \frac{2}{3}\boldsymbol{k_1} + \frac{1}{3}\boldsymbol{\mu} * \boldsymbol{c} + \frac{1}{3}\boldsymbol{\mu} * \boldsymbol{k_2}, \\ \frac{1}{3}\boldsymbol{a} - \frac{1}{3}\boldsymbol{c_0} + \frac{1}{3}\boldsymbol{c} + \frac{1}{3}\boldsymbol{k_2} - \frac{1}{6}\boldsymbol{\mu} * \boldsymbol{c} - \frac{1}{6}\boldsymbol{\mu} * \boldsymbol{k_2} \end{Bmatrix}$$

Proof. The solving process is similar with that listed in the Cournot game model above. For Developer 2, given the decision by Developer 1, there are two options: he may choose to develop genuine BEE products as well, or develop fake BEE products. In the former case, the quantity of genuine BEE products is given by maximizing the profit function:

$$\boldsymbol{Max\ R_2} = \boldsymbol{q_2} * (\boldsymbol{a} - \boldsymbol{q_1} - \boldsymbol{q_2} - \boldsymbol{c} - \boldsymbol{c_0} - \boldsymbol{k_2})$$

Yielding the condition for maximization, the best response function is:

$$q_{2T}^{**} = \frac{1}{2}(a - q_1 - c - c_0 - k_2)$$

Similarly, in the latter case, the quantity of fake BEE products is given by maximizing the profit function:

$$Max\ R_2 = q_2 * (a - q_1 - q_2 - c_0)$$

And the best response function is:

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

For Developer 1, given the possibilities of Developer 2, the quantity of genuine BEE products developed is given by maximizing the expected profit function:

$$MaxER_1 = \mu * q_1 * (a - q_1 - q_2^* - c - c_0 - k_1) + (1 - \mu) * q_1 * (a - q_1 - q_2^{**} - c - c_0 - k_1)$$

And the best response function is:

$$q_1^* = \frac{1}{2}[a - \mu * q_2^* - (1 - \mu) * q_2^{**} - c - c_0 - k_1] = \frac{1}{2}(a - Eq_2 - c - c_0 - k_1)$$

By solving the best response equations simultaneously, we get the Bayesian Nash Equilibriums above.

To further compare the impacts from transaction costs on each developer, the author compares the Bayesian Nash Equilibriums outlined in Proposition 4 with the unique Nash Equilibrium, presented in Proposition 3 with the premise of complete information. The purpose is to understand how the developer's optimum strategies will change accordingly in light of transaction costs incurred by uncertainties.

Proposition 5. *In the Bayesian Cournot game model between the developers with incomplete information, Developer 1, who develops genuine BEE products, will develop a smaller quantity of BEE, compare with that which would be develop in a complete information market, in light of transaction costs which may be incurred by uncertainties.*

Proof. According to Proposition 4, for Developer 1, the quantity of genuine BEE products he develops in *the Bayesian Cournot game model is given by:*

$$\boldsymbol{q_1^{**} = \frac{1}{3}a - \frac{1}{3}c_0 - \frac{2}{3}c - \frac{2}{3}k_1 + \frac{1}{3}\mu * c + \frac{1}{3}\mu * k_2}$$

According to Proposition 3, the quantity of BEE products he would develop in *the Cournot game model is given by:*

$$\boldsymbol{q_1^{*} = \frac{1}{3}(a - c - c_0 - k_1) - \frac{1}{3}(k_1 - k_2)}$$

The former minus the latter equals:

$$\boldsymbol{q_1^{**} - q_1^{*} = \frac{1}{3}(\mu - 1) * c + \frac{1}{3}(\mu - 1) * k_2}$$

As presented previously, the probability that Developer 2 would develop BEE is μ, and $0 \leq \mu \leq 1$, yielding that:

$$\boldsymbol{q_1^{**} \leq q_1^{*}}$$

As shown, for Developer 1, the quantity of BEE developed in the scenario with uncertainties is smaller than that with complete information, confirming the arguments that the transactions costs due to uncertainties in the BEE market have a negative impact on the supply side of BEE.

To a broader perspective, the total supply of BEE products would be affected by transaction costs in a market with complete information as well. As mentioned above, the probability μcould also be interpreted as the proportion of credible developers which develop genuine BEE products in the market, or a proxy to reflect the degree of fair competition in BEE markets. From the perspective of TCE, it can be as well used as an estimated proxy of transactions costs in different institutions.

Proposition 6. *In the Bayesian Cournot game model between developers with incomplete information, the total supply of genuine BEE products in market would*

decrease, if the proportion μ *of credible developers in the market decreases, implying that the unfair competition situation worsens BEE market development.*

Proof: In the market with complete information, according to Proposition 3, the quantity of genuine BEE products is given by:

$$\boldsymbol{q_1^* + q_2^* = \frac{2}{3}(a - c - c_0) - \frac{1}{3}(k_1 + k_2)}$$

In the market with incomplete information, we only concentrate on the genuine BEE products, rather than the total supply which may include fake BEE products. According to Proposition 4, the quantity of genuine BEE products is given by:

$$\boldsymbol{q_1^{**} + q_{2T}^{**} = \frac{2}{3}(a - c_0) - \left(\frac{5}{6} - \frac{1}{6}\mu\right) * c - \frac{1}{3}k_1 - \left(\frac{1}{2} - \frac{1}{6}\mu\right) * k_2}$$

The former minus the latter equals:

$$\boldsymbol{(q_1^* + q_2^*) - (q_1^{**} + q_{2T}^{**}) = \frac{1}{6}(1 - \mu) * c + \frac{1}{6}(1 - \mu) * k_2}$$

As the proportion μ of credible developers in a market follows: $0 \leq \mu \leq 1$, yielding that:

$$\boldsymbol{q_1^* + q_2^* \geq q_1^{**} + q_{2T}^{**}}$$

And the total supply of BEE products in a market with incomplete information, that is, $q_1^{**} + q_{2T}^{**}$ decreases, as the proportion μ decreases.

Conclusions:

- In a BEE market with uncertainties, developers will develop a smaller quantity of BEE products, comparing to a market with complete information. In light of transaction costs which occur due to uncertainties, the more severe the uncertainty is, the smaller quantity of BEE they would develop.
- From the perspective of the whole society, total supply of BEE products would decrease, if the incomplete information or the unfair competition situation worsens the BEE market. It implies the benefits brought by BEE to the welfare of society would decrease accordingly.
- Here, so far, we only consider a static game model between developers and ignored the impacts from the decisions of the end-users. Furthermore, suppose in a dynamic game model between developers with incomplete information, as the end-users realize there are fake BEE products in the market, the demand function of BEE products would move to the lower left, same as the price function outlined above. Therefore, the quantity of BEE products in the new equilibriums would decrease further, showing that incomplete information with unfair competition would undermine the reputation of BEE and jeopardize the long term healthy development of BEE.

The above game model can also be used to interpret the phenomenon of free rider in the BEE market from the perspective of TCE. For example, for each developer, it is necessary to make extra investments in design, R&D or advertising to develop BEE. If some developers choose to be free riders or invest inadequately, according to the above game model, the total supply of BEE products in the market would be smaller than it should be.

Policy implications:

- 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 government certainly plays an important and unique role providing regulations and incentives to reduce friction of unfair competition in the market. It will not only help developers to avoid unnecessary transaction costs, but also facilitates them in reducing the costs of BEE through competition. For public goods with a variety of externalities such as BEE, interventions from governments to secure a fair market is essential.

- The conclusions 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 conclusions 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.

4.2.3.3.2 Transaction costs from the perspective of discount rate

In the previous section, the impacts of transaction costs to the developers are analyzed from the perspective of uncertainties. From a broader view, the transaction costs associated with BEE not only come from external factors such as unfair competition in the BEE market, but also from internal factors, such as perception about risks in developing new product design, adapting to new regulations and entering into the unknown market, in terms of money and time. The measurement or estimation of these

transaction costs, either numerically or statistically, is very difficult from the perspective of TCE, since it is in many ways associated with the individual preference to BEE among different developers. For instance, to developers with skilled expertise in operation, or who are concerned more about a green image, sustainable strategies or social responsibilities, the transaction costs associated with BEE are of less concern compared to their market opponents. Instead of contemplating the degree of unfair competition in the BEE market, in practice, developers commonly adopt discount rates to offset the concerns from the transaction costs to BEE investment. In this section, the author extends the game model and focuses on the impacts of transaction costs from the perspective of discount rates.

Consider a Cournot game model of the BEE market in a two-developer setting, both with the same real estate development period, suppose it is t years[15], the developers make the investments in year 0, and get the revenues in year t. Let r_i denote the discount rate adopted by Developer i when he makes his decisions on BEE investment. Each developer determines the quantity of BEE he is about to develop by solving the following optimization problem:

$$\boldsymbol{Max\ R_i = \frac{1}{(1+r_i)^t} * q_i * P(Q) - C_i(q_i)}$$

Where R_i is the profit from developing BEE for Developer i, q_i is the quantity of BEE by Developer i, Q is the market supply of BEE products by Developer 1 and 2, $P(Q)$ is the price function of market supply of BEE products, $C_i(q_i)$ is the cost per unit to develop BEE for Developer i. For simplicity, suppose a linear cost function for Developer i, given by:

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

[15] Noted here there may be differences in development periods for different BEE projects, and it is commonly regarded that the shorter the period is, the less risks the developer is exposed to. . For simplicity, we assume for any BEE project, both developers have the same development period, using a comparable discount rate. Conclusions here also applied to cases with different development periods.

wherec_0 is the cost per unit to develop a conventional building, c is the extra cost per unit to develop BEE, k_i is the transaction cost per unit to develop BEE, q_i is the quantity of BEE developed by Developer i. $TC_i = k_i * q_i$ represents transaction costs involved for Developer i . We assume that information about costs is common knowledge for both developers. Let q_1^{****}denote the equilibrium quantity of BEE products by Developer 1, q_2^{****} denotes the equilibrium quantity of BEE products by Developer 2.

Proposition 7.*In the Cournot game model between developers with discount rates, the unique Nash equilibrium is given by:*

$$(\boldsymbol{q_1^{****}, q_2^{****}}) = \left\{ \begin{matrix} \frac{1}{3}\left[a + \frac{1}{(1+r_2)^t} * (c_0 + c + k_2) - \frac{2}{(1+r_1)^t} * (c_0 + c + k_1)\right], \\ \frac{1}{3}\left[a + \frac{1}{(1+r_1)^t} * (c_0 + c + k_1) - \frac{2}{(1+r_2)^t} * (c_0 + c + k_2)\right] \end{matrix} \right\}$$

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

$$q_1^* = \frac{1}{2}\left[a - q_2 - \frac{1}{(1+r_1)^t} * (c_0 + c + k_1)\right]$$
$$q_2^* = \frac{1}{2}\left[a - q_1 - \frac{1}{(1+r_2)^t} * (c_0 + c + k_2)\right]$$

Solving the two equations simultaneously, we have the Nash equilibrium (q_1^{****}, q_2^{****}) in Proposition 7.

As shown, if $r_1 = r_2 = 0$, $(q_1^{****}, q_2^{****}) = (q_1^*, q_2^*)$, which is outlined in Proposition 3. In fact, when discount rates are 0, implying that the developers both neglect the time risks associated with the process of BEE development, the equilibrium quantity of BEE developed is the same as that in the Cournot game model with complete information.

If $r_1 = r_2 > 0$, and $k_1 > k_2$, obviously, we have: $q_1^* < q_2^*$. It means that if the two developers have the same discount rate, the developer with lower transaction costs will develop a greater quantity of BEE products, and take up a larger market share.

If $r_1 > r_2 > 0$ and $\mathrm{k}_1 = \mathrm{k}_2$, obviously, we have: $\mathrm{q}_1^* > q_2^*$. It means that if the two developers have the same transaction costs to develop BEE, the developer with a higher discount rate will develop a greater quantity of BEE products, thus taking up a larger market share, and he would choose to invest in BEE now than in the future.

Furthermore, consider a special case, if $\mathrm{k}_1 > \mathrm{k}_2$, solve the conditions for $\mathrm{q}_1^{****} > q_2^{****}$, yielding that:

$$\boldsymbol{r_1 > (\frac{c_0 + c + k_2}{c_0 + c + k_1})^{\frac{1}{t}} * (1 + r_2) - 1}$$

It means that even if Developer 1 has higher transaction costs than Developer 2 in his BEE development, as long as the discount rate of Developer 1 satisfies the premise above, in the equilibrium, Developer 1 will develop a greater quantity of BEE than Develop 2 now and take a larger market share.

Conclusions and policy implications:

- The discount rate adopted by the developer is an important proxy to reflect the confidence and expectation he has in the BEE investment. The higher discount rate means a higher expectation of capital return, which in turn means less confidence in uncertainty, in terms of potential money, time and risks by BEE. The developers will discount the future revenues from BEE investment by a higher discount rate, by believing that transaction costs may occur in the development process.

- Transaction costs matter to the developers. If the two developers have the same discount rates, the developer with lower transaction costs is willing to develop more quantity of BEE and thus take up a larger market share.

- Market expectation is also an important factor to influence the developers' decision making on BEE. If the developer expects lower risks in the BEE market, even with a higher transaction cost, he will still decide to develop a greater quantity of BEE now and expect to take up a larger market share and gain long term competitiveness.

- As for the government, it is crucial to have long term strategies and clear policy signals for BEE promotion, in order to create a positive investment environment and raise the stakeholders' confidence and market expectation for business investment in BEE. For example, governments should formulate and implement a package of polices by taking into consideration the transaction costs impacts to the market stakeholders. Possible policies include unveiling the road map of energy and carbon taxes reform, ensuring the future business attraction of BEE products by setting up reasonable energy prices, raising up the awareness of BEE by advocating and educating the public on the urgency and importance in this matter, and setting up incentive schemes to reduce the costs for developers and end-users, etc.

- The above mentioned conclusions are of great value, especially for developing countries. For example, in China, energy subsidies are commonly deemed as part of social welfare. A lower energy price in turn creates an adverse incentive signal for the public and thus difficult for BEE development. Therefore, priorities in such a country should be given to a structural change by reforming energy pricing and taxation systems. Only in a uniform, transparent and predictable policy environment, would developers make the investments in BEE by expecting a better business potential with less transaction costs in future.

4. 3 GAME MODEL BETWEEN THE DEVELOPERS AND THE END-USERS

A comprehensive review and analysis of market barriers to both the developers and the end-users has been done in Chapter Three from the transaction costs perspective. It concludes that transaction costs are the key factors impeding BEE market penetration. Furthermore, by modeling the game between the developers and the end-users, we will look into the mechanism of market competition and the impacts of transaction costs on the stakeholders' decisions. The aim is to study how to facilitate the development of BEE by reducing the transaction costs incurred.

There is no doubt that the game between the developers and the end-users form the core transaction in a real estate market and it is obviously a complex multi-dimensional game problem during the whole real estate development process. Even though the decision by the end-users takes place mainly during the later stage of BEE development, i.e. sale and operation, etc., it affects the developers' strategies with regard to BEE design and development as well. By modeling the interactions between the developers and the end-uses from the perspective of TCE, additional insights will be gained to understand the underlying essence of the BEE market.

4.3.1 The context of game between the developers and the end-users

BEE is part of the real estate market. Before framing the model about BEE, the general nature and context of the transactions and games among the stakeholders in the real estate market should be investigated first. In general, the real estate market[16] is "the sum of real estate transactions" and "the bridge connecting real estate development and construction to final consumption, as well as the economic process where the value in use and value of real estate are realized" (Gao, 2004). It is characterized by some special features different from the common market, including "localized transactions[17], oligopoly competition, supply lag, diverse demands, investment or speculation, complex transactions, constrained by finance, government intervention and inefficiency" (Qiao,

[16] Definition of "real estate market"

[17] Influenced by population, environment, culture, education and economy, demand characteristics of real estate vary in various countries and regions, which is manifested as: zoning use of land, density control, fixity in land. Types of real estate market are usually different among different zones, and even various in the same zone.

2001). From the perspective of game theory, the game of transaction is much more complicated between the end-users and developers, compared with that just among developers:

First of all, information asymmetry is much more severe. For the developers, they are aware of the information about costs, quality and energy efficiency performance of real estate, as well as some knowledge about the preferences of end-users through market survey or extra studies of market expectation. By contrast, the end-users are at a disadvantage with respect to the knowledge and expertise about developing BEE. They only know their own preferences and willingness to pay, with rare knowledge of the real development costs, quality, the actual performance of BEE and its extra costs. In addition, as for the performance of energy efficient buildings, the degree of compliance of BEE codes cannot be easily observed and inspected before and even during operation. Besides, it cannot be explicitly stipulated as provisions in the purchase contract, making it a passive factor for end-users. Moreover, the uncertainties of energy efficiency performance due to the culture, behaviors and lifestyles of the individual end-users, can further worsen the information asymmetry problems.

Secondly, severe inequality in the game of the developers and end-users exists during the market transaction. For simplicity, gaming in the real estate market can be deemed as many small groups of transaction with one developer versus a number of dispersed end-users. It also makes sense to think of the real estate market with dramatically different bargaining powers- the experienced and dominant developers versus self-financed with limited professional knowledge end-users[18] . Moreover, as for a certain location, or a certain land parcel, the developer is the exclusive supplier of the real estate products. Once the decision is made and the building project is constructed, the end-users' preferences become less important and usually are difficult to please. Besides, as an oligopoly market, the developers prefer to supply real estate products with standardized floor layouts, design and existing networks with the manufacturers

[18] We say an agent has more/less bargaining power than its opponent if in the equilibrium the outcome is more/less favorable to it than to its opponent.

and suppliers. This results in less innovation to avoid risks from BEE, thus reducing development costs, but leaving limited choices for end-users[19].

Thirdly, apart from the energy performance of real estate, there are lots of external factors influencing the players' strategies in the game. The first one is the overall supply and demand status quo in the real estate market. When the overall supply exceeds demand for real estate, obviously, end-users will have more bargaining power in the game. The second one is the type of end-users, i.e., a self-consumer or an investor and speculator. Regarding energy efficiency performance, end-users for self-consumption usually will pay more attention; whilst the other type focuses more on property appreciation. Noted, with the rising level of incomes and increasing desire for property income, even for common end-users, concerns about the maintenance and appreciation of the property value will become more and more of the concern. The third external factor is macroeconomic policy condition. The real estate industry is typically capital intensive and policy sensitive, such as interest rates, finances and land policies, etc., which affect the strategies of all the stakeholders, especially the decision-making of the developers and end-users. The last external factor is the real estate cycle. "Real estate market is a very typical cyclical market, which moves in a circle of prosperity-plain-depression-recovery-prosperity. Housing price is at highest when in prosperity and at lowest when in depression" (Li, 2003). In particular, for many countries, real estate markets with significant cyclical prosperous, bubble and depressive features, the developers and end-users are both driven by anticipations about change in property value, with energy efficiency performance playing a much more trivial role.

It is empirically proved that apart from development costs, factors such as land price, bank credit, level of incomes and macroeconomic policies, etc., have important

[19] Noted, many factors affect the energy efficiency performance of real estate, including the architectural design condition, thermal insulation of wall, appliance efficiencies, operating maintenance etc. In many countries, the developer provides real estate products including appliances, so the consumer has little influences upon BEE level; while in some regions in China, what developer provides is roughcast house, some room is left to consumers to improve BEE level through decoration, and adoption of energy-saving appliances etc.

influences on the real estate price. Noguchi (1994) found that the main reason for the Japanese real estate bubble in 1980s was the surge of land price. Stuckenschmidt et al (2003) deemed that the housing price is directly affected by the land policy and the soundness of land market. Krugman (1999) pointed out that nearly all price bubbles in property markets were connected with an over-loosed credit environment. Allen and Gale (2009) further proved how the bank agency and other financial institutions led to asset bubble with modeling. The model indicated that the price formed in property investor's use of his/her own money is the price basis of real estate. For example, when investments are leveraged by loans from banks, risk transfer or asset substitution will be possible, and the risk-appetite investor need not bear all cost when investment conditions turn bad, which in turn results in asset price's deviation from price basis. Moreover, consumers' irrational psychology and the existing "herd behavior" will further the problems of the property bubble.

Last but not least, energy efficiency performance of real estate is not always the focal point in the game between the developers and the end-users. Many other factors, as discussed above, will affect the price of real estate. These include [20]: the quality of real estate, such as building design, layout, structure, energy efficiency performance; regional factors, such as regional design, traffic accessibility, environment and landscape, surroundings, public facilities; land factors, such as size, shape, frontage condition, infrastructures, topography, geological and hydrological conditions, planning and control conditions, term of land use right etc.; and architectural factors, such as depreciation degree, fitment, facilities, layout, construction quality, architectural structure, orientation and so on. To maximize the profits, the developers prefer to take differentiated product strategies by emphasizing the distinct features such as the favorable location, fashionable designs and comprehensive facilities whilst energy efficiency performance is only one feature. To maximize the utility, the end-users normally choose real estate products according to their preferences and affordability.

[20] The author concludes by referring to *National Standard Specification for Property Appraisal in People's Republic of China*.

Most likely, they are more sensitive to price, location, quality and facilities, comparing to its energy efficiency performance. For example, in China, the price and location of the real estate are likely to be the most important factors to the end-users, partially due to the uneven allocation of public services such as transportation, hospitals and education along with rapid urbanization. Therefore, BEE is widely neglected by end-users.

4.3.2 Modelling the game between the developers and the end-users

A game model is considered between the developers and the end-users with respect to BEE. In a general sense, “a transaction cost is incurred when an economic exchange happens among two or more parties, it thus must come from a game behavior. When there are a lot of parties involved, the game behavior approaches general equilibrium. Therefore, game theory is much more generic than general equilibrium analysis” (Wang, 1995). The problem is, yet, how to frame the game model exclusively on BEE, rather than having it affected by other unrelated factors. In a more specific way, the price of the real estate may be affected by its energy efficiency performance, as well as other factors such as location, layout, macroeconomic condition, etc. Instead of including all the general features of the real estate market, our objective is to investigate the main barriers prohibiting the development of BEE, from the perspective of transaction costs.

A game model with a developer and an end-user, suppose they have reached a preliminary agreement upon transaction of the real estate product, which is hypothetically a conventional building. Thus, the main problem in the game is to decide the extra price needed to persuade the developer into developing the real estate product to a BEE product, through the negotiation process to communicate and compromise to reach mutually beneficial outcomes. Once the developer and the end-user agree on the “extra price for BEE”, comparing to its conventional counterpart, and since they have already been assumed to reach to preliminary agreement on the transaction of conventional buildings, the BEE transaction will be through. This has been explained on page

The reason to assume the game modeling between developer and end-user, who have already reached a preliminary agreement upon transaction of conventional buildings, is because the author only wants to know how the extra part (price) of BEE, comparing with conventional one, affect the decision-making of the stakeholders. Therefore, the study object can naturally assume the parties agree on the conventional buildings, but hesitate on the extra part (cost/ price) that brought by the BEE. The assumption allows the game modeling to be simplified and straightforward to simulate the scenario on how the extra price due to BEE affect the decision-makings between the real estate developers. Once this is through, the transaction of BEE should be through by the stakeholders.

The model gives insightful assumptions well fit to the nature of the real estate market in practice, and looks into the barriers of BEE between the developers and the end-users in a systematic way. The reasons are as follows: firstly, the transaction of BEE at the micro level is actually happening between one developer and one end-user, negotiating the price for each given real estate product separately. Secondly, the whole BEE market can be abstractly deemed as the game between a hypothetical real estate developer and a hypothetical end-user, representing the aggregate supply and demand respectively. The equilibriums in the game are the total quantity of BEE developed in market and the average price of BEE. Thirdly, the game model can provide the foundation to further simulate the interactions in the BEE market, by considering the probability distributions of the developers and the end-users. Lastly, the hypothetic game model has clear definition about the payoffs of BEE, avoiding the unnecessary concerns and discussions about utilities from other improvements, such as property appreciation or comfort improvement, and the differences among countries, regions or development stages, making the conclusion more generic and applicable.

By and large, the game between the developer and the end-user is a typical Prisoner's Dilemma. For the developer, extra costs for developing BEE is necessary, as well as transaction costs incurred in the process of BEE development, whereas the benefit, in terms of higher price of BEE is dependent on preference of the end-user. For the end-user, energy efficiency performance and benefits associated with BEE cannot be

precisely observed at the initial stage, yet not fully guaranteed in the life cycle of BEE product. Suppose the developer and end-user both care only about maximizing their own utility, without any concern for the other's utility. Then the unique equilibrium for this game is a Pareto-suboptimal solution, that is, rational choice leads the developer not to develop, and the end-user not to purchase, even though each would be better off if they cooperate and share the extra benefit of energy efficiency improvement from BEE. Therefore, policy priorities for governments should be given to reducing the transaction costs and mobilizing the cooperation through institution improvement in the BEE market.

4.3.3 Transaction costs in the game between the developers and the end-users

A transaction is a process by which a good or service is transferred across a technologically separable interface (Williamson, 1975, 1985). Due to the market in reality are often inefficient (e.g., information asymmetry) and uncertain (e.g., product and process uncertainty), in order to process a transaction, customers must conduct activities such as searching for information, negotiating terms, and monitoring the on-going process to ensure a favorable deal (Coase, 1937). The costs involved with such transaction-related activities represent transaction cost. In other words, the total customer cost includes the buyer's time, energy, psychic and other costs. The buyer evaluates these elements together with the monetary cost to form a total customer cost

Based on Williamson's framework (1975, especially 1985), there are two cost components in any contract relationship: the ex ante and ex post costs. The ex ante costs are those associated with negotiating and establishing a contract. Part of these costs grows from extensive information gathering. A more pervasive and threatening source of ex ante costs is boundary rationality. Ex post costs are the actual, in contrast to expected, growth in prices borne by one or both members of a coalition after the contractual relationship has been forged. Williamson (1985, 21) includes among ex post costs "the mal adaption costs incurred when transactions drift out of alignment in relation to [previous expectations], … the haggling costs incurred if bilateral costs are

made to correct ex post misalignments,…the setup and running costs associated with the governance structures to which disputes are referred, and … the bonding costs of effecting secure commitments." More important, ex post and ex ante costs are interrelated. This interrelation leads to the pervasive risk of opportunism, the feature of human nature that causes people either to fabricate or to withhold critical cost-bearing information to another party.

Few studies have been carried out about the scale of transaction costs involved in the process of BEE development. Though, it is widely found that transaction costs in the BEE market increase very fast, with the expanding and complicating of the real estate industry. The reason is that end-users have only limited information regarding market profile, product quality in the real estate market, and mostly they have to finish the transactions through the help of real estate agencies, banks and brokers, with all the costs associated contributing to transaction costs. Take China as an example, the number of enterprises in the real estate industry, including developers, estate managements and real estate agencies, increased from 29000 to 137000 between 1992 and 2004, with gross revenue expanding from 52.1 billion RMB to 1474.1 billion RMB.

In a specific way, transaction costs in the game between the developers and the end-users include costs for searching, negotiating, contracting, monitoring and enforcement, so as to finish the transaction of the BEE product, compared with those for a conventional building product, in terms of money, time and risk. For developers, costs include market survey, extra studies of market requirements, learning know how about BEE, grasping government policies and regulations, negotiating, as well as setting up extra organizations and appointing special architects, in terms of money, time and risk. For the end-users, costs include searching information about market supply and demand, quality and energy efficiency performance of real estate, negotiating, as well as the extra costs for maintenance while in use, in terms of money, time and risk. From the perspective of TCE, the transaction costs are mainly incurred from the following issues:

The first is information asymmetry. As mentioned above, the developers and the end-users are asymmetric with respect to information about BEE, with the end-users in a relatively disadvantageous position. Mostly, the developers may overestimate the transaction costs for developing BEE, while the end-users may underestimate the benefits BEE would bring, leading to insufficient supply and demand of BEE. The special features of BEE, such as the postponed benefits after purchasing, the ambiguous energy efficiency performance of BEE associated with behavior, lifestyle and macroeconomic conditions, worsens the information gap regarding BEE.

The second is risk. In view of the innovative BEE products, developers have to take additional risks in the BEE market, design, construction and policies. Also, the end-users face additional time, money and energy cost for information searching and price negotiation upon BEE, as well as the uncertainties of less than expected energy efficiency performance and additional operating and maintenance cost in use. Besides, there are marginal costs of time for the developer and the end-user, which further add risks for either developing or purchasing the BEE product.

For simplicity and to maintain our emphases on the core questions, rather than involving the detailed costs associated with every transaction in the process of BEE development, we purposely concentrate on the total extra transaction costs needed, either for developing or purchasing the BEE product, compare with a conventional building product.

To conclude, transaction costs due to the above issues bring huge influence upon the decisions of developers and end-users with regard to BEE, even making the transaction of the BEE product unprofitable to each other. Therefore, it is of vital significance to analyze and understand in-depth the influence of transaction costs upon the game between the developers and the consumers, so as to further draw policy implications for promoting BEE development.

4.3.4 Game Model between the developers and the end-users

To provide a concrete setting for our study, the author presents a game model regarding BEE with a developer and an end-user, negotiating over the extra price needed in comparison with conventional building transactions, to finish the transaction of the BEE product. By investigating two scenarios with/without transaction costs in a comparative way, and taking consideration of uncertainties in a latter case, the author further looks into the impacts of transaction costs on developers and end-users in the BEE market, and draws policy implications to address the issues in a more generic context.

Suppose the developer and the end-user are economically rational and act strategically, the developer is to maximize his profit from developing a BEE product, and the end-user is to maximize his utility from purchasing the BEE product. As outlined above, suppose they have reached a preliminary agreement upon transaction of a hypothetically conventional building product, the focus of the game is to decide the extra price, for which the end-user is willing to pay and the developer is willing to do to develop the BEE product, while making the price as favorable to each as possible. Clearly, the equilibrium price for BEE, if existed, must be higher than the extra cost needed to develop it, and lower than the utilities it would bring to the end-user, otherwise the transaction will not be through.

In details, suppose for the developer, the extra cost needed to develop a BEE product is C, for the end-user, the additional utility brought from purchasing the BEE product is V, and $\mathrm{V} > C$. The developer and the end-user are negotiating about the price P for BEE. For simplicity, suppose the cost to develop a conventional building product and the utility from purchasing it are both 0. Suppose these presumptions are common knowledge for the developer and the end-user.

To solve the equilibrium in the game model, we regard it as a problem to fairly allocate the extra benefits brought by the BEE product between the developer and the end-user. As long as the BEE product is economically and technically feasible, both the developer and the end-user can mutually benefit from the transaction of BEE product, only

negotiating over exactly how to reach it. Put differently, on the one hand, the developer and the end-user both would like to reach some agreement upon the price of BEE, rather than disagree. On the other hand, each of them would like the price of BEE to be most favorable to himself.

The negotiation process has long been modeled using the tools of game theory, especially using bargaining theory, which is a natural framework that allows us to simulate the game between the developer and the end-user with respect to BEE from the micro point of view. In a specific way, bargaining theory introduced by Nash (1950, 1953) postulates a group of players choosing a payoff allocation from a set of feasible payoff allocations. The implementation of a payoff allocation requires unanimous agreement among the players. In the case of disagreement, the players end up getting some predetermined payoff allocation known as the status quo or the threat point. A bargaining solution is defined on class bargaining problems, assigning a feasible payoff allocation to each bargaining problem. (Qin, 2009)

A two-person bargaining problem is composed of a choice set $S \subset R^2$ of feasible payoff allocations the players can jointly achieve with agreement, and a threat point $d \in S$ the players end up getting in the case of disagreement. A bargaining solution on a class B of bargaining problem is a rule f assigning a feasible allocation $f(S,d) = (f_1(S,d), f_2(S,d)) \in S$ to each bargaining problem $(S,d) \in B$.

A positive affine transformation for player *i*'s payoff is a mapping $\tau_i: R \to R$ such that for some two real numbers $a_i > 0$ and b_i, $\tau_i(u_i) = a_i u_i + b_i$ for all $u_i \in R$. Given τ_1 and τ_2, $\tau(u) = (\tau_1(u_1), \tau_2(u_2))$ for all $u \in R^2$.

Nash considered the following well-known axioms on bargaining solutions.[21]

[21]Roth (1977) showed that a bargaining solution is strictly Pareto optimal whenever the solution satisfies SIR, INV, and IIA. Thus, with INV and IIA, Pareto optimality as Nash originally considered can be replaced by SIR.

- Strictly Individual Rationality (SIR): For any $(\mathbf{S}, \mathbf{d}) \in \mathbf{B}, \mathbf{f_i}(\mathbf{S}, \mathbf{d}) > \mathbf{d_i}, \mathbf{i} = \mathbf{1}, \mathbf{2}$.
- Symmetry (SYM): For any $(\mathbf{S}, \mathbf{d}) \in \mathbf{B}$ with $\mathbf{d_1} = \mathbf{d_2}$ and $(\mathbf{u_2}, \mathbf{u_1}) \in \mathbf{S}$whenever$(\mathbf{u_1}, \mathbf{u_2}) \in \mathbf{S}, \mathbf{f_1}(\mathbf{S}, \mathbf{d}) = \mathbf{f_2}(\mathbf{S}, \mathbf{d})$.
- Invariance to Equivalent Utility Representations (INV): For any $(\mathbf{S}, \mathbf{d}) \in \mathbf{B}$ and for any positive affine transformation:ד: $\boldsymbol{\mathcal{R}^2} \rightarrow \boldsymbol{\mathcal{R}^2}, \boldsymbol{f}\big(ד(\boldsymbol{S}), ד(\boldsymbol{d})\big) = ד\big(\boldsymbol{f}(\boldsymbol{S}, \boldsymbol{d})\big)$
- Independence of Irrelevant Alternatives (IIA): For any $(\mathbf{S}, \mathbf{d}), \big(\mathbf{S^1}, \mathbf{d}\big) \in \mathbf{B}$with $\mathbf{S} \subseteq \mathbf{S^1}$, $\mathbf{f}\big(\mathbf{S^1}, \mathbf{d}\big) \in \mathbf{S}$implies $\mathbf{f}(\mathbf{S}, \mathbf{d}) = \mathbf{f}\big(\mathbf{S^1}, \mathbf{d}\big)$.

When B is composed of compact convex bargaining problems with strictly Pareto dominated threat points, these four axioms uniquely characterize the symmetric Nash Bargaining solution: To each $(\mathrm{S}, \mathrm{d}) \in \mathrm{B}$ it assigns the payoff allocation determined by:

$$\underset{\boldsymbol{u \in S, u \geq d}}{\boldsymbol{max}} (\boldsymbol{u_1} - \boldsymbol{d_1})(\boldsymbol{u_2} - \boldsymbol{d_2})$$

See Nash (1953) and Roth (1979) for details.

When the symmetry axiom is removed, Kalai (1977) showed that for the class of compact convex bargaining problems, the bargaining solution that assigns the payoff allocation determined by the maximization of the Nash product weighted by bargaining powers α for player 1 and $1 - \alpha$ for player 2 is:

$$\underset{\boldsymbol{u \in S, u \geq d}}{\boldsymbol{max}} (\boldsymbol{u_1} - \boldsymbol{d_1})^{\boldsymbol{\alpha}} (\boldsymbol{u_2} - \boldsymbol{d_2})^{\mathbf{1-\alpha}}$$

4.3.4.1 Game Model between the developers and the end-users without transaction costs

Suppose the developer and the end-user are negotiating in a perfect market with zero transaction costs, implying that the information is perfect for each other, without any searching, negotiating, contracting, monitoring and enforcement costs in terms of time, money and risk. Thus, payoff to the developer can be expressed as the profit: price

minus cost; and payoff to the end-user can be expressed as: utility minus price. In the scenario without transaction costs, if benefit of the BEE product exceeds its cost ($\mathrm{V} > C$), obviously, the rational developer and the rational end-user will make an agreement upon the price through bargaining ($\mathrm{V} \geq \mathrm{P} \geq \mathrm{C}$), both with positive payoffs in the equilibrium. That is, the developer will develop the BEE product, and the end-user will purchase it at price$\mathrm{P}$.

According to the Nash Bargaining Theory, solving the equilibrium price of BEE agreed between the developer and the end-user in the BEE market can be expressed as solving the following optimization problem, given by:

$$\boldsymbol{\max_{P} Q = (P - C)^{\alpha}(V - P)^{1-\alpha}}$$

where Q represents the aggregate payoff of the developer and the end-user, let $\mathrm{Q_D} = \mathrm{P} - \mathrm{C}$ denote the payoff for the developer by developing the BEE product, let $\mathrm{Q_C} = \mathrm{V} - \mathrm{P}$ denote the payoff for the end-user by purchasing the BEE product, α and $1 - \alpha$ represent the bargaining powers for the developer and the end-user respectively.

Proposition 8.*The equilibrium price of the BEE product, that is, the Nash bargaining solution in the game model between the developer and the end-user without transaction costs is given by:*

$$\boldsymbol{P^{*} = \alpha V + (1 - \alpha)C}$$

And payoffs for the developer and the end-user are proportional to their bargaining powers.

Proof: To determine the Nash bargaining solution, we take the derivative of Q with respect to$\mathrm{P}$, and set it to zero for maximization:

$$\frac{\partial Q}{\partial P} = \alpha(P - C)^{\alpha-1}(V - P)^{1-\alpha} - (1 - \alpha)(P - C)^{\alpha}(V - P)^{-\alpha} = 0$$
$$\alpha(P - C)^{\alpha-1}(V - P)^{1-\alpha} = (1 - \alpha)(P - C)^{\alpha}(V - P)^{-\alpha}$$
$$\alpha(P - C)^{-1}(V - P) = 1 - \alpha$$

Yielding the equilibrium:

$$\boldsymbol{P^* = \alpha V + (1 - \alpha) C}$$

And the payoff for the developer:

$$\boldsymbol{Q_D = P^* - C = \alpha (V - C)}$$

The payoff for the end-user:

$$\boldsymbol{Q_C = V - P^* = (1 - \alpha)(V - C)}$$

Hence, we have:

$$\boldsymbol{\frac{Q_D}{Q_C} = \frac{\alpha}{1 - \alpha}}$$

We further extend the model to consider the externality of BEE from the perspective of society. As discussed above, the benefit of the BEE product, in terms of money, is dependent on various factors such as energy saving amount in life cycle of the BEE product, energy price, discount rate, as well as behavior and lifestyle of end-user. The higher the energy price is, the higher the benefit of the BEE product is, other things being equal.

As for energy price, the developer and the end-user usually take the current price or the expected price of energy in their decision making processes for evaluating the benefit from the BEE product. However, to solve the externality problems from the exploring and consuming of energy, the shadow price of energy, which incorporates lifetime damage cost associated with energy consumption, should be much higher from the perspective of society. In such situations, benefit of BEE should be higher too. Suppose it is V_1, and $V_1 > V$, yielding the equilibrium price of BEE from the perspective of society, suppose it is P_1^* , given by:

$$\boldsymbol{P_1^* = \alpha V_1 + (1 - \alpha) C > P^* = \alpha V + (1 - \alpha) C}$$

We can note that, since the market price of energy is mostly lower than the shadow price of energy when externalities are considered, and benefits of the BEE product are commonly undervalued in practice, hence, it is necessary for government to play an

effective role to correct the market signal through policies such as incentives, regulations and administrative measures.

Conclusions:

- In the game equilibrium without transaction costs, the rational developer will develop the BEE product, and the rational end-user will purchase it, if the benefit of the BEE product exceeds the cost.
- The equilibrium price of the BEE product is dependent on its cost, benefit, as well as the relative bargaining power between the developer and the end-user.
- The equilibrium payoffs for the developer and the end-user are proportional to their bargaining powers. The higher the bargaining power is, the more benefit it will gain from the transaction of the BEE product.
- From the perspective of society, the benefit of the BEE product is usually undervalued, with externalities considered.

Policy implications:

- In the scenario without transaction costs, it is beneficial for both the developer and the end-user, if the BEE product is feasible economically and technically. Reducing the transaction costs should be prioritized for the government, to promote the BEE market to an optimal level.
- The equilibrium amounts of BEE supply and demand are lower than the social optimal level, with externalities considered. Government interventions such as incentives, awareness rising are needed to promote the development of the BEE market.

4.3.4.2 Game Model between the developers and the end-users with transaction costs

A hypothesis is set as follows:

Hypothesis H4(GM)
At the unique equilibrium price of the BEE product in the game model between the developer and the end-user with transaction costs , the payoffs for the developer and the end-user are less than those in the scenario without transaction costs, and

proportional to their bargaining powers.

By solving the Nash bargaining solution of the game model without transaction costs outlined above, we concluded that the transaction of the BEE product is feasible and possible, as long as the benefit of the BEE product exceeds its cost. However, as discussed in Section 4.3, due to the inevitable transaction costs associated with searching, negotiating and monitoring for both the developer and the end-user, the transaction of the BEE product in the real world may not happen, and the price of the BEE product mostly varies from the equilibrium price in the game model. In the following part, we will introduce transaction costs as a whole in a systemic game model to explore the impacts on the developer and the end-user.

Suppose associated with transaction of the BEE product, the transaction cost for the developer is$\mathrm{TC_D}$, for the end-user is $\mathrm{TC_C}$, which are common knowledge for both. In such situation, the cost to develop the BEE product is higher, and the benefit of the BEE product is lower, compared with those in the scenario without transaction costs.

Proposition 9.*The unique equilibrium price of the BEE product in the game model between the developer and the end-user with transaction costs is given by:*

$$\boldsymbol{P^{**} = \alpha V + (1-\alpha)C + (1-\alpha)TC_D - \alpha TC_C}$$

And the payoffs for the developer and the end-user are given by:

$$\boldsymbol{Q_D^* = P^{**} - C - TC_D = \alpha(V - C - TC_C - TC_D)}$$
$$\boldsymbol{Q_C^* = V - TC_C - P^* = (1-\alpha)(V - C - TC_C - TC_D)}$$

which are less than those in the scenario without transaction costs, and proportional to their bargaining powers.

Proof: In the game model with transaction costs, solving the equilibrium price of the BEE product can be expressed as solving the following optimization problem, given by:

$$\max_{P} \boldsymbol{Q} = (\boldsymbol{P} - \boldsymbol{C} - \boldsymbol{TC_D})^{\alpha}(\boldsymbol{V} - \boldsymbol{TC_C} - \boldsymbol{P})^{1-\alpha}$$

Take the derivative of Q with respect to P, and set it to zero for maximization:

$$\frac{\partial \boldsymbol{Q}}{\partial \boldsymbol{P}} = \boldsymbol{0}$$

Yielding the equilibrium price:

$$\boldsymbol{P^{**}} = \boldsymbol{\alpha}(\boldsymbol{V} - \boldsymbol{TC_C}) + (\boldsymbol{1} - \boldsymbol{\alpha})(\boldsymbol{C} + \boldsymbol{TC_D}) = \boldsymbol{\alpha V} + (\boldsymbol{1} - \boldsymbol{\alpha})\boldsymbol{C} + (\boldsymbol{1} - \boldsymbol{\alpha})\boldsymbol{TC_D} - \boldsymbol{\alpha TC_C}$$

And the payoff for the developer:

$$\boldsymbol{Q_D^*} = \boldsymbol{P^{**}} - \boldsymbol{C} - \boldsymbol{TC_D} = \boldsymbol{\alpha}(\boldsymbol{V} - \boldsymbol{C} - \boldsymbol{TC_C} - \boldsymbol{TC_D})$$

The payoff for the end-user:

$$\boldsymbol{Q_C^*} = \boldsymbol{V} - \boldsymbol{TC_C} - \boldsymbol{P^*} = (\boldsymbol{1} - \boldsymbol{\alpha})(\boldsymbol{V} - \boldsymbol{C} - \boldsymbol{TC_C} - \boldsymbol{TC_D})$$

And clearly:

$$\frac{\boldsymbol{Q_D^*}}{\boldsymbol{Q_C^*}} = \frac{\boldsymbol{\alpha}}{\boldsymbol{1} - \boldsymbol{\alpha}}$$

As supposed previously, $\mathrm{TC_C}, \mathrm{TC_D} > 0$, compared with the payoffs in the game model without transaction costs, then we have:$\mathrm{Q_D^*} < \mathrm{Q_D}$ and $\mathrm{Q_C^*} < \mathrm{Q_C}$.

Consider the precondition of the transaction, in the game model without transaction costs, the transaction would be viable as long as $\mathrm{V} > C$. In the game model with transaction costs, however, the transaction would be through only if $\mathrm{V} > C + \mathrm{TC_D} + \mathrm{TC_C}$, demonstrating that it is more difficult for the developer and the end-user to reach an agreement if high transaction costs are involved.

In addition, we compare the equilibrium price of the BEE product above with that in the game model without transaction costs, yielding that:

$$P^{**} = P^{*}, \text{ if } \alpha = \frac{TC_D}{TC_C+TC_D}.$$
$$P^{**} > P^{*}, \text{ if } \alpha < \frac{TC_D}{TC_C+TC_D}.$$
$$P^{**} < P^{*}, \text{ if } \alpha > \frac{TC_D}{TC_C+TC_D}.$$

Hence, the change of equilibrium price of BEE is related to the relative bargaining power and transaction costs of the developer and the end-user with respect to BEE. The higher the bargaining power is for the end-user, the lower the price of the BEE product is in the equilibrium, other things being equal.

Conclusions:

- The condition for the transaction of the BEE product is stricter, comparing with that in the scenario without transaction costs. That is to say, the higher the transaction costs associated are, the more difficult it is for the developer and the end-user to reach an agreement over the transaction of the BEE product.
- Payoffs for the developer and the end-user in the scenario with transaction costs are proportional to their bargaining powers. The payoffs are less than those without transaction costs, and decrease with the transaction costs escalating.
- The game model also highlights the behaviors of the developers and the end-users in the real world. On the one hand, the developers will stress or exaggerate the difficulties, risks and uncertainties, as well as the transaction costs associated, in order to secure his bargaining power over price during the negotiation of BEE. On the other hand, the end-users will emphasize the uncertainties about the energy efficiency performance of BEE, in addition to the transaction costs in terms of money, time and risk, so as to ask for the lowest price possible in the negotiation.

Policy implications:

- Reducing the transaction costs, either associated in the process of the BEE development, or incurred in the process of BEE purchasing, will facilitate the supply and demand of BEE in market, benefiting the developer and end-user both.
- Given the asymmetric information in the real world, in terms of reducing transaction costs in the BEE market, governments can play a proactive role in areas such as R&D in BEE technologies, awareness raising, dissemination of innovative design and pilot projects, etc.

4.3.4.3 Further discussions about transaction costs

In the previous parts, by framing the game model between the developer and end-users with respect to BEE with/without transaction costs, we discuss the general impacts from transaction costs on the decisions of developers and end-users, concluding that transaction costs are the overriding barriers impeding the development of the BEE market.

As argued above in Chapter four, it is not only the scale of transaction costs which matters in the BEE market, but also their determinants. The determinants of transaction costs, according to Oliver E. Williamson, are frequency, specificity, uncertainty, limited rationality, and opportunistic behavior. Put differently, in reality of course it is impossible to quantify each detailed transaction cost in the BEE market, and imagine that the developers and the end-users effectively identify and execute the best or most rational strategy accordingly at every stage, due to the constraints from limited rationality and opportunistic behavior. Besides, it is difficult to decide the frequency of transactions in the BEE market, since it is a one-time deal for most end-users whilst a repeated one for most developers.

In this regard, we will further improve the game model with consideration of uncertainties, investigating the detailed impacts of transaction costs. On the one hand, rather than focusing on the precise scale of transaction costs for the developer and the end-user, the assumption of uncertainties makes the model more realistic and universal. On the other hand, by analyzing the differences between the perceived and actual

uncertainties from the perspective of the developers and the end-users, more light will be shed on the impacts from limited rationality and opportunistic behavior as well.

4.3.4.3.1Transaction costs from the perspective of uncertainties

Transaction costs due to uncertainties from information asymmetry are the fundamental barriers in the game between the developer and the end-user in the BEE market. The uncertainties come either from the nature or feature of transaction over the BEE product, such as costs in acquiring associated information and difficulty in evaluating the real benefit from energy efficiency improvement, or from the unexpected changes in other factors, such as the market situation, preferences, macroeconomic conditions or energy prices. It is reasonable, thus, to assume rational developers and end-users will make their decisions based on maximization of their expected utilities, taking into account the various transaction costs due to uncertainties.

Followed Bayesian game theory and John C. Harsanyi's framework, we extend the bargaining game model outlined above into one with incomplete information. According to the analyses over the BEE market in previous parts, we frame the model in which there is a monopoly developer facing a mass of heterogeneous end-users. Assume that the developer may be one of two types, he may develop the BEE product and sell it to the end-user, or he may develop a conventional building. Suppose only in the former situation, he will negotiate with the end-user over the price of the BEE product, and the transaction of the BEE product will be through if they reach an agreement. The developer and the end-user are both economically rational and act strategically, the developer is to maximize his profit from developing the BEE product, and the end-user is to maximize his utility from purchasing the BEE product.

To formalize the ideas, suppose for the developer, the extra cost needed to develop the BEE product is C, and for the end-user, the additional utility brought from purchasing the BEE product is V, and $\mathrm{V} > C$. The developer and the end-user are negotiating about the price P for BEE. For simplicity, suppose the cost to develop a conventional building product and the utility from purchasing it are both 0. Similar with the analyses above in

section 4.3, we can model the negotiation process as a bargaining problem, suppose α and $1-\alpha$ represent the bargaining powers for the developer and the end-user respectively.

In the scenario with incomplete information, we assume that the type of the developer belonging to the group starting with the two-point probability distribution, that is, the probability is p if he develops the BEE product, and $1-\mathrm{p}$ if he does not. In the situation when the developer chooses to develop the BEE product, for simplicity, suppose the extra cost needed to develop the BEE product C is common knowledge. The utility that the end-user gains from purchasing the BEE product is private information. In other words, the developer does not know the utility of each end-user ex ante and just knows the distribution. Without losing generality, we assume the utility V follows the continuous uniform distribution on$[0, \mathrm{M}]$, where M is the highest extra utility the end-user may gain from purchasing the BEE product.

In more details, we only focus on the situation when the developer chooses to develop the BEE product and negotiates with the end-user over the price of BEE. If transaction costs are considered, suppose $\mathrm{TC_D}$ and $\mathrm{TC_C}$ denote transaction costs associated to reach an agreement for the developer and the end-user respectively. Noted that in contrast to common cost C for developing BEE, we suppose information regarding transaction costs is private information.[22] Noteworthy those assumptions above also reflect the fundamental characteristics of the BEE market. Statistically speaking, the probability distribution of the developer can be interpreted as the proportion of credible developers which develop BEE products in the market, while the probability distribution of the end-user can be regarded as the distribution of end-user demand with varied willingness to pay.

[22] As discussed previously, in the complete information scenario, transaction costs can be regarded the same as common costs for developing or purchasing BEE product, as an indispensable for both the developer and the end-user. In the asymmetric information scenario, we divide the transaction costs into two parts, one is common knowledge and the other is not.

Consider the game process, in the situation when the developer chooses not to develop BEE, then extra utilities for the developer and the end-user are both 0. In the situation when the developer$V$ develops BEE, if the price of the BEE product P exceeds the benefit V for the end-user, the end-user will choose not to negotiate and the transaction will not occur, then the payoff for the developer is $-C$, and the payoff for the end-user is 0.

Only in the situation when the price of the BEE product P is smaller than the benefit V for the end-user, will the developer and the end-user start to negotiate over the price. In addition, if there is an agreement in the end, the payoff for the developer is $P - C - TC_D$, while the payoff for the end-user is $V - P - TC_C$, due to the transaction costs incurred. If they fail to reach an agreement, the payoff for the developer is $-C - TC_D$, and the payoff for the end-user is $-TC_C$. The complete game tree is shown in Fig 5.1.

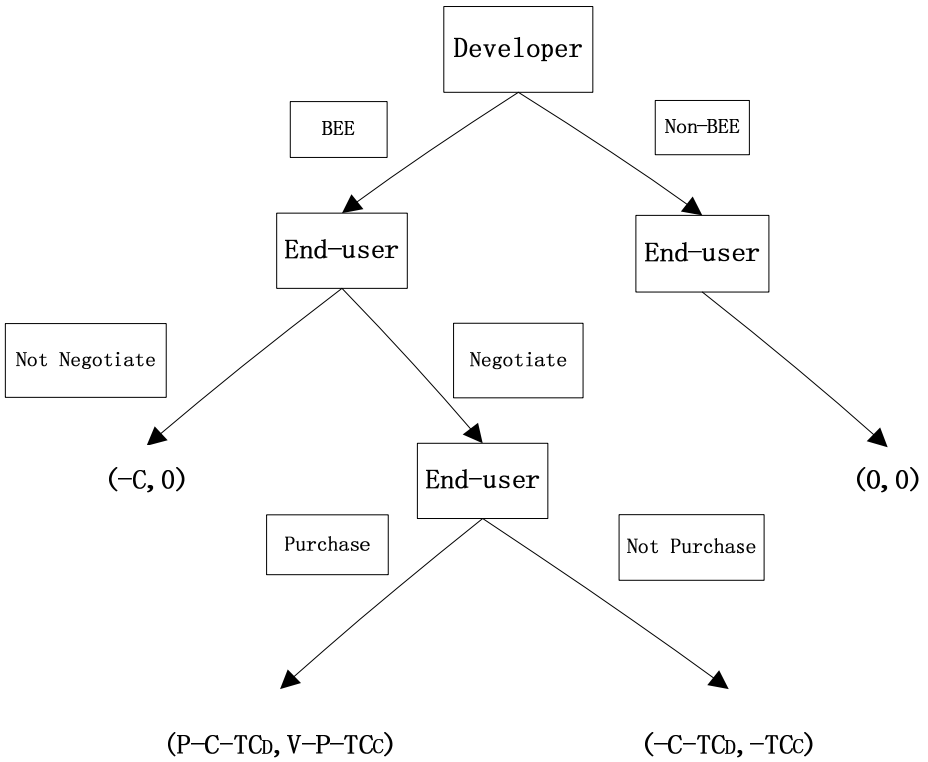

Figure 4.1 Game Tree for the game between the developer and the end-user

Equilibrium outcomes for the end-user:

From above we can conclude it is a typical **Stackelberg competition**[23]**-**Leader-Follower game between the developer and the end-user. The developer will decide whether or not develop the BEE product first, while his decision is dependent on the beliefs about the moves by the end-user. Therefore, we adopt the backward induction to solve the equilibriums in the game, investigating the optimal decisions by the end-user first. The reason is that, only when the end-users get his optimal choice, the transaction will go through; with the optimal decision, the developer will make his decision in order to complete the transaction.

Proposition 10.*The end-user will negotiate with the developer and purchase the BEE product if the benefit is* $\mathrm{V} \geq \mathrm{C} + \frac{\mathrm{TC_C}}{1-\alpha}$*, and will not purchase the BEE product if* $\mathrm{V} < C + \frac{\mathrm{TC_C}}{1-\alpha}$*. The expected utility for the end-user is given by:*

$$\boldsymbol{EQ_C} = \begin{cases} \boldsymbol{p}[(\boldsymbol{1}-\boldsymbol{\alpha})(\boldsymbol{V}-\boldsymbol{C})-\boldsymbol{TC_C}], & \boldsymbol{if\ V} \geq \boldsymbol{C} + \dfrac{\boldsymbol{TC_C}}{\boldsymbol{1}-\boldsymbol{\alpha}} \\ \boldsymbol{0}, & \boldsymbol{if\ V} < C + \dfrac{\boldsymbol{TC_C}}{\boldsymbol{1}-\boldsymbol{\alpha}} \end{cases}$$

Proof: For the end-user, we consider the optimum decision by investigating his reactions in different situations separately.

If the end-user believes that the developer will not develop the BEE product, then the best response for the end-user is not to negotiate nor purchase it, with the payoff being 0. If the end-user believes the developer will develop the BEE product, then he has three

[23] The model is solved by backward induction. The leader considers what the best response of the follower is, i.e. how it will respond once it has observed the quality of the leader. The leader then picks a quantity that maximises its payoff, anticipating the predicted response of the follower. The follower actually observes this and in equilibrium picks the expected quantity as a response. (http://en.wikipedia.org/wiki/Stackelberg_competition)

strategies: “not negotiate, not purchase”, “negotiate, not purchase”, “negotiate, purchase”, with the payoffs being 0, $-\mathrm{TC_C}$, $\mathrm{V}-\mathrm{P}-\mathrm{TC_C}$ respectively.

Obviously, when the developer chooses to develop the BEE product, the end-user will not choose the strategy of “negotiate, not purchase”, which is a strictly dominated strategy. Thus, the end-user will only choose between “not negotiate, not purchase”, or “negotiate, purchase”. If the expected payoff is positive, the end-user will choose to negotiate and purchase the BEE product. If the expected payoff is negative, the end-user will choose not to negotiate and not purchase the BEE product.

In more detail, to solve the equilibrium price of the BEE product, we solve the following optimization problem, given by:

$$\boldsymbol{\max_{P} Q = (P - C)^{\alpha}(V - P)^{1-\alpha}}$$

Set the first derivative of Q with respect to P to zero for maximization:

$$\boldsymbol{\frac{\partial Q}{\partial P} = 0}$$

Yielding the equilibrium price:

$$\boldsymbol{P^{*} = \alpha V + (1 - \alpha) C}$$

And the expected payoff for the end-user is given by:

$$\boldsymbol{EQ_C = p * (V - P^{*} - TC_C) + (1 - p) * 0 = p[(1 - \alpha)(V - C) - TC_C]}$$

Solving $\mathrm{EQ_C} \geq 0$, we have:

$$\boldsymbol{V \geq C + \frac{TC_C}{1 - \alpha}}$$

Compared with the scenario without transaction costs, the expected utility is less, due to:

$$\boldsymbol{EQ_C < Q_C = (1-\alpha)(V-C)}$$

And consider the precondition of the transaction, in the scenario without transaction costs, the transaction would be through as long as $\mathrm{V} > C$. Here, because $\frac{\mathrm{TC_C}}{1-\alpha}$ is positive, demonstrating that it is more difficult for the developer and the end-user to reach an agreement, and the market demand is decreasing due to higher transaction costs, as well as lower bargaining power for the end-users.

Beside, since the expected utility $\mathrm{EQ_C}$ is a monotone increasing function with respect to the probability p, that is, the higher probability is if the developer develops the BEE product, the more expected utility there is for the end-user.

Conclusions and policy implications:

- The decisions regarding BEE products for the end-users are related to the utility perceived from purchasing the BEE product, the development cost, the transaction costs associated and end-user's bargaining power.

- From the perspective of governments, the market demand for BEE products can be promoted through increasing the expected utility for the end-user, i.e., raising the probability or proportion that the developer chooses to develop BEE products, increasing the benefit for the end-user, subsidizing the extra costs to develop BEE for the developer, reducing the transaction costs associated or strengthening the bargaining power for the end-user.

- As for the supply side, incentive measures should be implemented to raise the probability or proportion that the developers choose to develop BEE products, which will increase the expected utility for the end-users through purchasing the BEE product, benefiting the long-term development of the BEE market.

- The game model is framed in a setting with one developer and one end-user, and could also be applied to the whole real estate sector. From a broad view, a real estate sector with a high proportion of developers focusing on BEE and green-oriented development will reduce the overall transaction costs associated, increasing the payoffs for the end-users.

- The static game model outlined above also has policy implications for the dynamic situation. In the long run, along with information diffusion, technology advancement, awareness increasing and institution improvement, the utility threshold $\mathbf{C} + \frac{\mathbf{TC_C}}{\mathbf{1-\alpha}}$ will be decreasing gradually, boosting the demand for BEE products.

- From the perspective of TCE, we adopt the probability $\mathbf{p}$ as an indicator to reflect the scale of transaction costs perceived by the end-user. Besides, the probability $\mathbf{p}$ could be interpreted from the perspective of reputation model or industrial structure, i.e., the probability $\mathbf{p}$ perceived by the end-users will be decreasing if there are more fake BEE products or less credible developers, resulting in higher transaction costs for the end-users and lower payoffs expected.

Equilibrium outcomes for the developer:

Two hypotheses are set as follows:

Hypothesis H5 (GM)
If the developer chooses to develop BEE products, the expected utility will increase with the improvement of utility for the end-user from purchasing the BEE product.
Hypothesis H6 (GM)
If the developer chooses to develop BEE products, the expected utility will decrease with the increase of development cost of BEE or transaction costs for the developer.

Given the optimum decisions for the end-user in different situations, we consider the optimum decision for the developer in a similar way.

If the developer believes that the end-user will not purchase the BEE product, then the best response for the developer is not to develop, with the payoff being 0. If the developer believes the end-user will negotiate and purchase the BEE product, then the developer will develop the BEE product, and has three strategies: "not negotiate, not sell", "negotiate, sell" and "negotiate, not sell", with the payoffs being $-\mathrm{C}$, $\mathrm{P}-\mathrm{C}-\mathrm{TC_D}$, $-\mathrm{C}-\mathrm{TC_D}$, respectively.

Similar with the analyses on optimum decisions for the end-user previously, when the developer chooses to develop the BEE product, then he will not choose the strategies of "not negotiate, not sell" or "negotiate, not sell", which are both dominated strategies. Therefore, the developer will only choose between "not develop" or "negotiate, sell" after developing the BEE product, choosing the former if the expected utility is negative, and the latter if it is positive.

Proposition 11. *The developer will develop the BEE product and sell it to the end-user through negotiation if the transaction costs associated satisfy the following constraints:*

$$\boldsymbol{TC_C \leq (1-\alpha)(M-C)}$$
$$\boldsymbol{TC_D \leq \frac{\alpha}{2}(M-C+\frac{TC_C}{1-\alpha})}$$

The developer will not develop the BEE product if:

$$\boldsymbol{TC_C} > (1-\alpha)(M-C) \textbf{ or } \boldsymbol{TC_D} > \frac{\boldsymbol{\alpha}}{\boldsymbol{2}}(\boldsymbol{M}-\boldsymbol{C}+\frac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}})$$

And the expected utility for the developer is given by:

$$\boldsymbol{EQ_D} = \begin{cases} \dfrac{\boldsymbol{\alpha}}{\boldsymbol{2M}}\left(\boldsymbol{M}+\dfrac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}-\boldsymbol{C}-\dfrac{\boldsymbol{2TC_D}}{\boldsymbol{\alpha}}\right)\left(\boldsymbol{M}-\boldsymbol{C}-\dfrac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}\right), \\ \boldsymbol{if\ TC_C} \leq \boldsymbol{(1-\alpha)(M-C)\ and\ TC_D} \leq \dfrac{\boldsymbol{\alpha}}{\boldsymbol{2}}(\boldsymbol{M}-\boldsymbol{C}+\dfrac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}) \\ \boldsymbol{0}, \\ \boldsymbol{if\ TC_C} > \boldsymbol{(1-\alpha)(M-C)\ or\ TC_D} > \dfrac{\boldsymbol{\alpha}}{\boldsymbol{2}}(\boldsymbol{M}-\boldsymbol{C}+\dfrac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}) \end{cases}$$

Proof: According to the optimal decisions for the end-user above, as well as the hypothesis of continuous uniform distribution on $[0, \mathrm{M}]$ for utilities of the end-users, for the developer, the end-user will choose to negotiate and purchase the BEE product if and only if the utility$\mathrm{V}$ satisfies:

$$\boldsymbol{C}+\frac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}} \leq \boldsymbol{V} \leq \boldsymbol{M}$$

Then the expected payoff for the developer is given by:

$$\boldsymbol{EQ_D} = \int_{\boldsymbol{C}+\frac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}}^{\boldsymbol{M}} (\boldsymbol{P^*}-\boldsymbol{C}-\boldsymbol{TC_D}) * \frac{\boldsymbol{1}}{\boldsymbol{M}}\boldsymbol{dV}$$

To solve the equilibrium price of the BEE product, refer to the proof of Proposition 10, which has:

$$\boldsymbol{P^*} = \boldsymbol{\alpha V} + \boldsymbol{(1-\alpha)C}$$

Consequently, the expected utility for the developer can be transformed as:

$$\boldsymbol{EQ_D} = \int_{\boldsymbol{C}+\frac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}}^{\boldsymbol{M}} (\boldsymbol{P^*}-\boldsymbol{C}-\boldsymbol{TC_D}) * \frac{\boldsymbol{1}}{\boldsymbol{M}}\boldsymbol{dV} = \int_{\boldsymbol{C}+\frac{\boldsymbol{TC_C}}{\boldsymbol{1-\alpha}}}^{\boldsymbol{M}} [\boldsymbol{\alpha}(\boldsymbol{V}-\boldsymbol{C})-\boldsymbol{TC_D}] * \frac{\boldsymbol{1}}{\boldsymbol{M}}\boldsymbol{dV}$$

Solving the integral problem, yielding the expected utility:

$$\boldsymbol{EQ_D = \frac{\alpha}{2M}(M + \frac{TC_C}{1-\alpha} - C - \frac{2TC_D}{\alpha})(M - C - \frac{TC_C}{1-\alpha})}$$

Since $\frac{\alpha}{2M} \geq 0$, and the inequality$M - C - \frac{TC_C}{1-\alpha} \geq 0$ holds due to $C + \frac{TC_C}{1-\alpha} \leq V \leq M$, thus to solve $EQ_D \geq 0$, we have:

$$\boldsymbol{TC_D \leq \frac{\alpha}{2}(M - C + \frac{TC_C}{1-\alpha})}$$

As proved, for the developers, the decisions over developing BEE products are related to the distribution of utilities of the end-users, the development costs for BEE, the transaction costs and the bargaining powers. Furthermore, suppose the BEE products are developed, we will investigate the impacts on the expected utilities for the developer from factors such as utilities of end-users, development cost, transaction costs and bargaining powers.

Proposition 12. *If the developer chooses to develop BEE products, the expected utility will increase with the improvement of utility for the end-user from purchasing the BEE product.*

Proof: Take the derivative of EQ_D with respect to M, we have:

$$\boldsymbol{\frac{\partial EQ_D}{\partial M} = \frac{\alpha}{2} + \frac{\alpha}{2M^2}(\frac{TC_C}{1-\alpha} - C - \frac{2TC_D}{\alpha})(C + \frac{TC_C}{1-\alpha})}$$

When the developer chooses to develop BEE products, implying that:

$$\boldsymbol{TC_D \leq \frac{\alpha}{2}(M - C + \frac{TC_C}{1-\alpha})}$$

the end-user chooses to negotiate and purchase the BEE product if and only if the utility$V$ satisfies:

$$\boldsymbol{C + \frac{TC_C}{1-\alpha} \leq V \leq M}$$

Then,

$$\boldsymbol{M - C - \frac{TC_C}{1-\alpha} \geq 0}$$

Then we have:

$$\frac{\partial EQ_D}{\partial M} = \frac{\alpha}{2} + \frac{\alpha}{2M^2}\left(\frac{TC_C}{1-\alpha} - C - \frac{2TC_D}{\alpha}\right)\left(C + \frac{TC_C}{1-\alpha}\right) \geq \frac{\alpha}{2} - \frac{\alpha}{2M}\left(C + \frac{TC_C}{1-\alpha}\right)$$
$$= \frac{\alpha}{2M}\left(M - C - \frac{TC_C}{1-\alpha}\right) \geq 0$$

To conclude, if the developers believe it is profitable to develop BEE products, the higher utilities the end-users will gain from BEE products, the more profits the developers will expect from developing BEE, other things being equal. In other words, since M also reflects the distribution of market demand for BEE, the expected profits for the developers will be boosted if demand for BEE products increases.

Proposition 13. *If the developer chooses to develop BEE products, the expected utility will decrease with the increase of development cost of BEE or transaction costs for the developer.*

Proof: Take the derivatives of $\mathrm{EQ_D}$ with respect to C and $\mathrm{TC_D}$ respectively, we have:

$$\frac{\partial EQ_D}{\partial C} < 0$$
$$\frac{\partial EQ_D}{\partial TC_D} < 0$$

Clearly, the expected profits from developing BEE products will be lower, if the developers face higher development costs and transaction costs associated.

Proposition 14. *If the developer chooses to develop BEE products, the expected utility for the developer will increase with the increase of transaction costs for the end-user, if the transaction costs for the end-user satisfy:*

$$TC_C < \frac{2(1-\alpha)}{\alpha} TC_D$$

The expected utility for the developer will decrease with the increase of transaction costs for the end-user, if the transaction costs for the end-user satisfy:

$$TC_C \geq \frac{2(1-\alpha)}{\alpha} TC_D$$

Proof: Take the derivatives of EQ_D with respect to $\mathrm{TC_C}$, yielding:

$$\frac{\partial EQ_D}{\partial TC_C} = -\frac{\alpha TC_C}{M(1-\alpha)^2} + \frac{2TC_D}{M(1-\alpha)}$$

Then we have:

$$\frac{\partial EQ_D}{\partial TC_C} > 0, \text{ if } 0 < TC_C < \frac{2(1-\alpha)}{\alpha} TC_D.$$
$$\frac{\partial EQ_D}{\partial TC_C} \leq 0, \text{ if } TC_C \geq \frac{2(1-\alpha)}{\alpha} TC_D.$$

Hence, for the developer, there is a threshold of transaction costs for the end-user, set $\frac{2(1-\alpha)}{\alpha} TC_D = \theta$, if the transaction costs for the end-user is smaller than θ, the expected utility for the developer will increase with the increase of transaction costs for the end-user. If the transaction costs for the end-user are larger than θ, the expected utility for the developer will decrease with the increase of transaction costs for the end-user.

The reason is as follows: with the increase of transaction costs for the end-user, the equilibrium price of the BEE product through negotiation between the developer and the end-user will decrease accordingly. On the one hand, when transaction costs for the end-user are small, the possibility that the end-user will purchase the BEE product is relatively high; thus, the expected utility for the developer may increase, even with the increase of transaction costs for the end-user. On the other hand, when transaction costs for the end-user are big enough, not only is the possibility for the transaction of the BEE product decreasing, but also the equilibrium price is lower, thus, the expected utility for the developer may decrease with the increase of transaction costs for the end-user.

Proposition 15. *If the developer chooses to develop BEE products, the expected utility for the developer will increase with the increase of his bargaining power, if the bargaining power for the developer satisfies:*

$$0 < \alpha < 1 - \frac{\sqrt{TC_C(TC_C - 2TC_D)}}{M - C}$$

The expected utility for the developer will decrease with the increase of his bargaining power, if the bargaining power for the developer satisfies:

$$\mathbf{1} - \frac{\sqrt{\boldsymbol{TC_C(TC_C - 2TC_D)}}}{\boldsymbol{M - C}} < \alpha < 1$$

Proof: Take the derivatives of $\mathrm{EQ_D}$ with respect to α, yielding:

$$\frac{\boldsymbol{\partial EQ_D}}{\boldsymbol{\partial \alpha}} = \frac{\boldsymbol{(M - C)^2}}{\boldsymbol{2M}} - \frac{\boldsymbol{TC_C}}{\boldsymbol{M(1 - \alpha)^2}}\left(\frac{\boldsymbol{TC_C}}{\boldsymbol{2}} - \boldsymbol{TC_D}\right)$$

Since $0 < \alpha < 1$, then we have:

$$\frac{\boldsymbol{\partial EQ_D}}{\boldsymbol{\partial \alpha}} > 0, \textbf{ if } \boldsymbol{0 < \alpha < 1 - \frac{\sqrt{TC_C(TC_C - 2TC_D)}}{M - C}}.$$
$$\frac{\boldsymbol{\partial EQ_D}}{\boldsymbol{\partial \alpha}} < 0, \textbf{ if } \boldsymbol{1 - \frac{\sqrt{TC_C(TC_C - 2TC_D)}}{M - C} < \alpha < 1}.$$

Hence, there is threshold of bargaining power for the developer, other things being equal. Set$1 - \frac{\sqrt{\mathrm{TC_C(TC_C - 2TC_D)}}}{\mathrm{M - C}} = \varphi$, the expected utility for the developer will increase with the strengthening of his bargaining power α, if $0 < \alpha < \varphi$. The expected utility for the developer will decrease with the strengthening of his bargaining power α, if $\varphi < \alpha < 1$.

The reason is similar with that in Proposition 14. When the bargaining power for the developer is relatively low, the expected utility for the developer will increase with the strengthening of his bargaining power, since the equilibrium price of the BEE product will increase accordingly. However, when the bargaining power for the developer is relatively high, despite increasing equilibrium price, the probability for the transaction of the BEE product is lowering, leading to the decreasing of expected utility for the developer.

To further look into the impacts from transaction costs on the optimum decision for the developer, we consider two scenarios with/without transaction costs. To make it simple, we only consider the transaction costs incurred in the negotiation process between the developer and the end-user.

Suppose in the scenario with transaction costs, the developer will choose to negotiate with the end-user over the transaction of the BEE product, its expected utility $\mathrm{EQ_D}$ is

given as in Proposition 11. In the alternative scenario without transaction costs, there is neither a negotiating nor a bargaining process, instead, suppose the developer puts a fixed price for the BEE product, let P_1denote the fixed price. Therefore, the end-user will only purchase the BEE product if the fixed price is smaller than the utility, that is, $\mathrm{V} \geq \mathrm{P}_1$. In this scenario, the developer has to find the optimal price to maximize his expected utility, let $\mathrm{EQ}_{\mathrm{D}}^{1}$ denote the new expected utility.

In the scenario without transaction costs, we have:

$$\boldsymbol{EQ_D^1 = \int_{V \geq P_1}^{M} (P_1 - C) * \frac{1}{M} dV = \int_{P_1}^{M} (P_1 - C) * \frac{1}{M} dV = (M - P_1)(P_1 - C) * \frac{1}{M}}$$

To find the optimal fixed price of the BEE product, we solving the following maximization problem, given by:

$$\boldsymbol{\max_{P_1} EQ_D^1 = (M - P_1)(P_1 - C) * \frac{1}{M}}$$

Set $\frac{\partial \mathrm{EQ}_{\mathrm{D}}^{1}}{\partial \mathrm{P}_1} = 0$, yielding the optimal fixed price:

$$\boldsymbol{P_1 = \frac{M + C}{2}}$$

And the expected utility for the developer is:

$$\boldsymbol{EQ_D^1 = \frac{(M - C)^2}{4M}}$$

Noted here the outcome is just the extreme case of the general model outlined above when transaction costs for the developer and the end-user during the negotiation and bargaining process are both 0, with the same bargaining power.

Proposition 16. *For the developer, the expected utility is bigger in the scenario with transaction costs than that in the scenario without transaction costs, if:*

$$\boldsymbol{TC_D \leq \frac{\alpha}{2}\left(M - C + \frac{TC_C}{1-\alpha}\right) - \frac{(M-C)^2}{4(M - C - \frac{TC_C}{1-\alpha})}}$$

The expected utility is smaller in the scenario with transaction costs than that in the scenario without transaction costs, if:

$$\boldsymbol{TC_D > \frac{\alpha}{2}\left(M - C + \frac{TC_C}{1-\alpha}\right) - \frac{(M-C)^2}{4(M - C - \frac{TC_C}{1-\alpha})}}$$

Proof: Solving the inequalities$\mathrm{EQ_D} \geq \mathrm{EQ_D^1}$ and $\mathrm{EQ_D} < \mathrm{EQ_D^1}$ respectively, we can deduce the outcomes above.

$\mathrm{TC_D} \leq \frac{\alpha}{2}\left(\mathrm{M} - \mathrm{C} + \frac{\mathrm{TC_C}}{1-\alpha}\right) - \frac{(\mathrm{M}-\mathrm{C})^2}{4(\mathrm{M}-\mathrm{C}-\frac{\mathrm{TC_C}}{1-\alpha})}$, which means the developers actually enjoy the transaction costs and get better off because of it! Also, it means that the developers would rather choose to negotiate and bargain with the end-users instead of setting a designate price. While $\mathrm{TC_D} > \frac{\alpha}{2}\left(\mathrm{M} - \mathrm{C} + \frac{\mathrm{TC_C}}{1-\alpha}\right) - \frac{(\mathrm{M}-\mathrm{C})^2}{4(\mathrm{M}-\mathrm{C}-\frac{\mathrm{TC_C}}{1-\alpha})}$, it means in this scenario, the developers would prefer to set a designate price rather than negotiate with the end-users due to the higher transaction costs. Therefore, the developers could be able to choose a different price to determine strategy to maximize their expected utility.

Noteworthy here it provides us additional insights about transaction costs. In some cases, the developer will choose strategies with higher transaction costs to maximize the expected profits. The reason is as follows: in the scenario without transaction costs, implying there are no negotiations, the developer charges the same price for the end-users whose utility is higher than the fixed price of the BEE product. By contrast, in the scenario with transaction costs, the developer with higher bargaining power might be better off due to price discrimination through negotiation, if the transaction costs associated are relatively low.

Conclusions and policy implications:

- The decisions over developing BEE products for the developer are related to the distribution of utilities of the end-users, the development costs for BEE, the transaction costs and the bargaining powers for the developer and the end-user.

- From the perspective of governments, the market demand for the BEE product can be promoted through increasing the expected utility for the developer, i.e. increasing the benefits of BEE products, reducing the development costs and transaction costs associated through incentive measures, energy or carbon taxes, etc.

- From the perspective of TCE, reducing the transaction costs associated in the development process of BEE can increase the expected utilities for the developers, expanding market supply of BEE product.

- As for the supply side, if the transaction costs faced by the end-user are relatively high, reducing the transaction costs of the end-users can increase the expected utilities for the developer. However, if the transaction costs for the end-user are relatively low, reducing the transaction costs may decrease the expected utilities for the developer.

- From the perspective of bargaining powers, strengthening the bargaining power for the developer can increase the expected utility of developing BEE products. Meanwhile, if the bargaining power for the developer is already high enough, further enhancing the bargaining power for the developer might decrease the expected utility of developing BEE products due to the retreat from the end-users.

- Transaction costs may affect the pricing strategies of the developer. If the transaction costs are relatively high, the developer prefers to adopt a fixed price strategy. If the transaction costs associated are relatively low, the developer prefers to negotiate with the end-users, gaining more transaction surplus through price discrimination.

4.3.4.3.2 Transaction costs from the perspective of discount rate

Two hypotheses are set as follows:

Hypothesis H7 (GM)
The expected payoff for the end-user in the game model between the developer and the end-user with discount rates is smaller than that in the scenario without transaction costs and discount rate.
Hypothesis H8 (GM)

The expected payoff for the developer in the game model between the developer and the end-user with discount rates is smaller than that in the scenario without transaction costs and discount rate.

In the previous parts, we investigate the impacts from transaction costs by modeling the game between the developers and the end-users, comparing the equilibriums in two scenarios with/without transaction costs. Further analyses are carried out regarding transaction costs from the perspective of uncertainties, where probability distributions are taken into consideration to characterize the transaction costs due to the perceived uncertainties.

As observed, stakeholders in the BEE market face various uncertainties, which come not only from the strategies of their opponents, but also from issues in terms of time, risk and information, etc. From the perspective of TCE, due to constraints from limited rationality and opportunistic behavior, it is impossible for neither the developer nor the end-user to accurately contemplate the uncertainties numerically or statistically at each stage of the decision making process. The reason is: for the end-user, the benefits from the BEE product depend on the product quality, behavior, lifestyle and macroeconomic factors such as energy price, which can only be verified through the life circle of the building, for the developer, he faces unknown risks and uncertainties from policy, unfair competition and changes in market or macroeconomic environments, further exacerbating the difficulties to take optimum decisions.

In practice, the developers and the end-users commonly take discount rates to evaluate the uncertainties and risks associated with the BEE product, which actually can be used to evaluate the transaction costs from another aspect. In this section, we will extend the above mentioned game model to analyze the impacts of transaction costs from the perspective of discount rates, which could include the whole transaction process into the consideration. Instead of just the negotiation process between the developer and the end-user, the model includes the life cycle of the real estate development process for the developer and the purchasing and operating process for the end-users. For

simplicity, we suppose the developer and the end-user are both aware of the transaction costs involved and consider them in the discount rates, that is, the bigger the transaction costs are, the higher the discount rate will be chosen. Noted that the discount rate is not only an indicator with financial meaning, but also related to the perceptions regarding BEE products by the developer and the end-user in the decision making processes.

Consider a game model with one developer and one end-user, suppose for the developer, the development process of BEE products is t_1 years, the developer make the investments in year 0, and get the revenues in year t_1, let r_1 denote the discount rate adopted by the developer when deciding on BEE investments. The payoff for the developer, which is discounted to year 0, is given by:

$$\boldsymbol{Q_D'} = \frac{\mathbf{1}}{(\mathbf{1}+\boldsymbol{r_1})^{\boldsymbol{t_1}}}\boldsymbol{P} - \boldsymbol{C}$$

Where $\mathrm{Q_D}'$ is the payoff to the developer with consideration of discount rate, P is the price of the BEE product, C is the cost needed to develop the BEE product.

Suppose to the end-user, the life cycle for the BEE product is t_2 years, the end-user purchases the BEE product in year 0, suppose the overall life cycle benefit from the BEE product is V, for simplicity, suppose the overall benefit has been discounted to year t_2, let r_2 denote the discount rate adopted by the end-user when deciding on the BEE product. Thus, the payoff for the end-user, which is discounted to year 0, is given by:

$$\boldsymbol{Q_C}' = \frac{\mathbf{1}}{(\mathbf{1}+\boldsymbol{r_2})^{\boldsymbol{t_2}}}\boldsymbol{V} - \boldsymbol{P} < Qc$$

Suppose these priors are common knowledge for the developer and the end-user.

Proposition 17. *The equilibrium price of the BEE product in the game model between the developer and the end-user with discount rates is given by:*

$$\boldsymbol{P^{**} = \frac{\alpha}{(1+r_2)^{t_2}} V + (1-\alpha)(1+r_1)^{t_1} C}$$

Proof: To determine the equilibrium price of BEE product, we solve the Nash bargaining problem:

$$\boldsymbol{\max_P Q = \left(\frac{1}{(1+r_1)^{t_1}} P - C\right)^{\alpha} \left(\frac{1}{(1+r_2)^{t_2}} V - P\right)^{1-\alpha}}$$

Take the derivative of Q with respect to P, and set it to zero for maximization, we have:

$$\boldsymbol{P^{**} = \frac{\alpha}{(1+r_2)^{t_2}} V + (1-\alpha)(1+r_1)^{t_1}}$$

Proposition 18.*The equilibrium price of the BEE product with discount rates is smaller than that in the scenario without transaction costs, if the discount rate for the developer satisfies the following condition:*

$$\boldsymbol{r_1 < log_{t_1}\left\{1 + \left[1 - \frac{1}{(1+r_2)^{t_2}}\right]\frac{\alpha C}{(1-\alpha)V}\right\} - 1}$$

And it is bigger than that in the scenario without transaction costs, if the discount rate for the developer is:

$$\boldsymbol{r_1 \geq log_{t_1}\left\{1 + \left[1 - \frac{1}{(1+r_2)^{t_2}}\right]\frac{\alpha C}{(1-\alpha)V}\right\} - 1}$$

Proof: As mentioned above in Proposition 8, the equilibrium price in the scenario without transaction costs is given by:

$$\boldsymbol{P^* = \alpha V + (1-\alpha) C}$$

Compared with the equilibrium price in the scenario with discount rate, yielding that:

$$\boldsymbol{P^{**} < P^*}\text{, if } \boldsymbol{\frac{(1+r_2)^{t_2}-1}{(1+r_2)^{t_2}\left[(1+r_1)^{t_1}-1\right]} > \frac{\alpha C}{(1-\alpha)V}}$$
$$\boldsymbol{P^{**} \geq P^*}\text{, if } \boldsymbol{\frac{(1+r_2)^{t_2}-1}{(1+r_2)^{t_2}\left[(1+r_1)^{t_1}-1\right]} \leq \frac{\alpha C}{(1-\alpha)V}}$$

Translate the conditions for the discount rate of the developer, deducing the outcomes above.

Furthermore, we extend the game model with uncertainties by taking into account discount rates, and look into the synthetic impacts on decisions by the developer and the end-user, so as to capture more insights on impacts from associated transaction costs. Let $\mathrm{EQ}_{\mathrm{C}}^{1}$ and $\mathrm{EQ}_{\mathrm{D}}^{1}$ denote the payoffs for the developer and the end-user in the scenario with discount rate respectively:

Proposition 19. *The expected payoff for the end-user in the game model between the developer and the end-user with discount rates is given by:*

$$\boldsymbol{EQ_C^1 = p * (1-\alpha)\left[\frac{1}{(1+r_2)^{t_2}}V - (1+r_1)^{t_1}C\right]}$$

which is smaller than that in the scenario without transaction costs and discount rate.

Proof: According to the game model with uncertainties outlined above, suppose the probability is p if the developer develops the BEE product, and $1-\mathrm{p}$ if he does not. Then the expected payoff for the end-user in the scenario with discount rate is given by:

$$\boldsymbol{EQ_C^1 = p * \left(\frac{1}{(1+r_2)^{t_2}}V - P^{**}\right) + (1-p) * 0 = p * (1-\alpha)\left[\frac{1}{(1+r_2)^{t_2}}V - (1+r_1)^{t_1}C\right]}$$

According to Proposition 10, let $\mathrm{EQ}_{\mathrm{C}}^{0}$ denote the expected payoff for the end-user in the scenario without transaction costs and discount rate, which is given by:

$$\boldsymbol{EQ_C^0 = p * (1-\alpha)(V-C)}$$

Since $\mathrm{r}_1, \mathrm{r}_2 > 0$, then we have:

$$\boldsymbol{(1+r_1)^{t_1}, (1+r_2)^{t_2} > 1}$$

Concluding that:

$$\boldsymbol{EQ_C^1 < EQ_C^0}$$

Proposition 20. *The expected payoff for the developer in the game model between the developer and the end-user with discount rates is given by:*

$$\boldsymbol{EQ_D^1 = \frac{\alpha}{2M(1+r_2)^{t_2}}[M-(1+r_1)^{t_1}(1+r_2)^{t_2}C]^2}$$

which is smaller than that in the scenario without transaction costs and discount rate.

Proof: According to the game model with uncertainties outlined above, for the end-user, the utility V from purchasing a BEE product follows the continuous uniform distribution on $[0, \mathrm{M}]$, considering the condition for the end-user to negotiate with the developer, based on proposition 19, which is given by:

$$\boldsymbol{EQ_C^1 \geq 0}$$

Yielding that:

$$\boldsymbol{V \geq (1+r_1)^{t_1}(1+r_2)^{t_2}C}$$

Then the expected payoff for the developer is given by:

$$\boldsymbol{EQ_D^1 = \int_{(1+r_1)^{t_1}(1+r_2)^{t_2}C}^{M}(P^{**}-C)*\frac{1}{M}dV}$$

Solving the integral problem, we have:

$$\boldsymbol{EQ_D^1 = \frac{\alpha}{2M(1+r_2)^{t_2}}[M-(1+r_1)^{t_1}(1+r_2)^{t_2}C]^2}$$

According to Proposition 11, let $\mathrm{EQ_D^0}$ denote the expected payoff for the developer in the scenario without transaction costs and discount rate, which is given by:

$$\boldsymbol{EQ_D^0 = \frac{\alpha}{2M}(M-C)^2}$$

Since $\mathrm{r}_1, \mathrm{r}_2 > 0$, then we have:

$$\boldsymbol{(1+r_1)^{t_1}, (1+r_2)^{t_2} > 1}$$

Concluding that:

$$\boldsymbol{EQ_D^1 < EQ_D^0}$$

Conclusions and policy implications:

- Discount rates adopted by the developer and the end-user, as the probabilities perceived in the scenario with uncertainties, are both important proxies reflecting the concerns when making decisions regarding BEE products in view of transaction costs in the BEE market.
- The equilibrium price of the BEE product will increase if the developer adopts a high discount rate while anticipating high transaction costs associated in the process of BEE development, other things being equal, further prohibiting the end-user from entering the BEE market.
- Both the developer and the end-user will discount the expected payoffs from the BEE product, in light of transaction costs which may be incurred.
- As for governments, it is crucial to have long term strategies and comprehensive policy systems to improve the prospect for the developers and the end-user to engage in the BEE market. For example, incentive measures such as preferential loans, subsidies and grants, tax exemptions and deductions can be used to increase the life cycle attraction of the BEE product to market stakeholders.

The game modeling part is mainly theoretical analysis. However, since both the game modeling and the empirical studies are then triangulated to draw the overall findings. The game modeling findings have, therefore, gone through the test of empirical findings from the industry. These overlapping findings between the theoretical and empirical part of the study are cross referencing to each other and have been both tested and validated by each other through the triangulation analysis.

CHAPTER FIVE: DATA COLLECTION AND ANALYSIS

Overview

This chapter covers the data collection and analysis from both the interviews and the questionnaire survey. The purpose of the interviews **(5.1-5.3)** with real estate developers and their professional representatives in Hong Kong is to identify the specific transaction costs concerns in actual practice by focusing on the local market. Detailed questions were designed to ascertain the underlying issues raised in previous chapters. The questionnaire survey **(5.4-5.5)** was given to building designers from both Hong Kong and Singapore to investigate from a broader view how the general business's concerns for "green building" affect market stakeholders' interest in investing in BEE.

5.1 INTERVIEW SURVEY WITH REAL ESTATE DEVELOPERS AND THEIR REPRESENTATIVES

Most research that has applied cost-benefit analysis (CBA) to BEE has shown that developers believe that green building is ultimately beneficial to them. However, there is little research to ascertain the developers' concerns about transaction costs (invisible costs or hidden costs, including risks and time, as opposed to capital costs). This part of the research aims to understand the actual transaction costs for developers building BEE projects in Hong Kong.

5.1.1 Why in-depth interview the real estate developers?

Real estate developers are the dominant force in the building market. As most incentive schemes are market-based and voluntary, the stakeholders involved are free to accept or reject them. There are two major reasons that real estate developers are not motivated by most of the existing incentive schemes. First, the extra transaction costs involved are too heavy and the developers would rather give up potential benefits to avoid the attendant difficulties; second, the benefits from the schemes are not enough,

which means that the incentive itself is not a sufficient inducement for the potential investors to become involved.

The real estate developers and their professional representatives who took part in the interviews are all from the top six real estate development companies in Hong Kong, which undertake about 80% of the real estate development there. Fifteen interviews were conducted with the directors of these real estate development companies or their professional representatives, such as architects and project managers.

Profiles of the interviewees:

1. VC: (Executive Director of E&M Engineering)
2. MT: (Executive Director of one of the top developers)
3. KS: (Sustainable development director for a leading architectural firm)
4. FC:: (Associate Director of a world-class architectural firm)
5. PE: (Director of one of the top 2 QS firms)
6. SK: (Director, Campus Development of a Hong Kong university)
7. JP: (senior officer, Environmental Protection Department)
8. SM: (Director of a medium size QS firm)
9. SY: (Director, one of the top developers)
10. Q: (Director of one of the top developers)
11. NB: (Chairman of a leading property services company)
12. TM: (Director of an international property investment company)
13. WC: (Director, Science Park)
14. KC: (Managing Director of a surveyor company Ltd., and past president of the Professional Green Building Council)
15. EC: (Architect, and Honorary Secretary of the Professional Green Building Council)

The personal experience of the interviewees in developing/ managing BEE projects is essential to this research. As in Hong Kong, most of the real estate development (~ 80%) is done by the top 6 real estate development companies, it is important to include those interviewees who are coming from these top 6 real estate development companies. As the decision-makings and strategic plans for the real estate development- whether BEE or not, and market expectations/ concerns to BEE, are only done by people who are senior and stay high position. In addition, we select those people who have definitely got the practical experience on BEE, and could influence the market in a significant way.

Therefore, the 15 interviewees are selected with the above considerations to ensure the sample is representable and the results are significant.

5.1.2 Design of the interview questions

The interview questions were designed to address three major theoretical dimensions of transaction costs: specific investment, frequency, and uncertainty. Seven hypotheses regarding these three aspects were developed, and related open questions about the interviewees' opinions were designed to test each of them. In addition, a framework (see Figure 3.3 of Chapter 3) showing the possible extra tasks and related transaction costs to be considered under the *Architect's Outline Plan of Work* is established for interview-data collection. The interviewees were asked to identify the additional concerns and work involved in BEE in terms of the transaction costs incurred during each stage of the real estate development process, and to rank them by level of uncertainty.

The hypotheses and the interview questions were designed based on the literature review and discussions with a few experts in industry and academia. The relations between the three dimensions, seven hypotheses (H), and sixteen interview questions (Q) are listed in Tables 5.1, 5.2, and 5.3 below. Remarks explain how the interview questions relate to the hypotheses. The purpose of these interviews is to supplement the findings from the theoretical game model (Chapter Four) and the BCI survey with building designers (2nd Section of Chapter Five), by using an in-depth local case study from the developers' viewpoint to ascertain the concerns and transaction costs in practice at each stage of the real estate development process that may affect the decision-making of the real estate developers.

5.1.2.1 Hypotheses and Questions for Specific Investment

Table 5.1 Specific Investment

H1	Dividing the transactions of the real estate development (RED) process into smaller established stages helps government to better understand the process and make

	policies with a more focused emphasis on the different stages of transaction to promote BEE more efficiently.
Q1	Which are the stages of greatest concern to the developers in the RED process?
Q2	What are the reasons that make developers willing to invest in new BEE technology without government incentives? What price difference (% of development cost) would be acceptable?
Q3	Uneven emphasis on incentives: What facilities/building elements are more expensive/difficult to be retrofitted, if not installed in the first place? Should they be emphasized in incentives to promote BEE investment?
Q4	For developers investing in BEE, what are the different concerns of investing in luxury buildings and in lower-priced buildings? Why?
Q5	There is misplaced benefit between the people who pay and who gain from BEE. To address this problem, would rental/selling-price differences help?

Remarks

Specific investment in BEE increases the workloads of developers and the resources they need, which increases their concerns as they decide whether to make a BEE investment.

Hypothesis (H1) proposes that in securing a detailed understanding of the BEE elements, such as technologies, appliances, or inputs for specific investments, it is better to break down the real estate development process into its component stages (Q1), by the difficulty of retrofits (Q3), by the type of buildings (luxury or low-price), (Q4). The purpose of these questions is to determine whether the policies can be designed for a highly specific group with effective incentives for securing investments in BEE.

Q2 is to elicit the underlying reasons and the approximate limit (as percentage of the development budget) that the developers would be willing to invest in BEE without incentives from the government. The purpose is to see if the government could create a business environment conducive to BEE with any market interventions.

Q5 addresses one of the most notorious features of BEE – misplaced interests – in order to understand how they affect the current situation, determine what about them concerns developers, and determine what, if any, resolution is called for by the market.

These five interview questions collectively address, from different perspectives, the issues raised by Hypothesis H1. The open question format allows the interviewees to talk freely about their concerns in a wider context.

5.1.2.2 Hypotheses and Questions for Frequency of BEE investment

Table 5.2 Frequency

H2	There is a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects.
Q6	Will the size of the project affect the developers' concerns about BEE investment?
Q7	Will the size of the RED company affect the developers' concern about BEE investment?
H3	There is a positive relationship between the frequency of BEE investments and the transaction costs incurred in developing BEE projects.[24]
Q8	How does the frequency (e.g., regular, occasional, or at one-time) of developers' BEE investments affect their concerns about BEE investment?
Q9	Would the developers' concerns change if they invested in BEE projects more frequently? Why?

Remarks

The frequency of BEE transactions is another dimension that affects transaction costs. How frequently the developers invest in BEE may affect their concerns differently. The transaction costs may thus change accordingly (H3).

Q8 and Q9 are the two questions that address the relationship between the level of concerns about BEE investment and the frequency of BEE transactions. The nature of this relationship may help governments design different policies to encourage investment by frequent and occasional investors by taking into account their different concerns.

[24] There are a few concerns here: 1. The transaction costs will increase along with the frequency of transactions. However, due to economies of scale, the transaction costs per transaction will decrease accordingly. 2. Concerns about BEE investments will differ among regular investors and occasional ones. One possibility is that occasional investors just invest once and do not worry too much about the consequences of the investment; their expectations of government incentives and returns may not be as high as those of regular investors.

The size of the company and the size of the project also affect investors' capacity to invest and, therefore, the frequency with which they do so (H2). Big companies may have different concerns and strategies than smaller ones when it comes to BEE investments (Q7). To integrate green features into bigger projects may have different impacts in terms of transaction costs, compared to smaller ones (Q6).

To understand how changing concerns are a function of the size of the RED company or project and the frequency of BEE investment requires knowing market segmentation according to both size and frequency. This information allows government to design and specify incentives for more focused groups.

5.1.2.3 Hypotheses and Questions for Uncertainty

Table 5.3 Uncertainty

Economic uncertainty	
H4	The economic context (upturn or downturn economic transition) affects the concerns of the real estate developers about BEE investment.
Q10	At times of economic transition, what new challenges or opportunities arise for investments in BEE? How do shifts in the economy change the developers' major concerns (neutral, positive, or negative) and in which aspects?
Q11	When the direction of the economy shifts, how might developers integrate green features into original investments to increase market competitiveness?
H5	Changes in economic conditions (upturns and downturns) call for the attention of government to adjust BEE policies as necessary to seize BEE development opportunities.
Q12	What role should government play in BEE promotion (more intervention or less intervention in a recessionary economy)?
Q13	What BEE promotions or incentive could government introduce in times of economic change that would be less upsetting to the market players' normal activities?
Market uncertainty	
H6	The end-users' variable expectations about BEE increase market uncertainty to the developers (e.g. ., they may misinterpret a focused group as the end-users of their final products.)
Q14	Occupants' behavioral differences may lead developers to produce different BEE/GB at different performance levels. What is your view?
Q15	Will concerns about social classes (different education levels, experiences,

	financial ability to enjoy the benefits of BEE) affect the developers' concern about BEE investment?
Policy uncertainty	
H7	The earlier the stage of BEE policy implementation, the greater the real estate developers' concerns about transaction costs.
Q16	Would a new incentive and a currently mature incentive affect the developers' concerns about BEE differently? In other words, encountering BEE incentives, would the developers have more concerns during the early or later stage of the implementation of the incentive? How are they different?

Remarks

Uncertainty about BEE investments is one of the general features of transaction costs that causes real estate developers worry. Uncertainty is examined in this study from three perspectives: economic uncertainty, market uncertainty, and policy uncertainty.

What is the impact of economic transition on the BEE development (to the developer – H4; to the government – H5)? Is it a challenge or an opportunity? How do the developers' concerns change in an economic downturn or upturn? What should government be alert to during such periods and how can it develop the most effective policies to promote BEE accordingly? These are the main issues that are addressed in interview questions Q10- Q13.

The market also creates many uncertainties for developers. They may be hesitant to invest in BEE due to a lack of confidence in estimations of market demand. The end-users' expectations and concerns about BEE may be better known, so that both the developers and the government could seize the opportunity to promote BEE. This brings H6 onto the horizon. Q14 and Q15 are designed to detail the behavior and concerns of the market end-users about BEE by segmenting the customers so that the real estate developers might have a more confident business strategy and so that the government can design its incentive policies to cater to more focused groups based on a better understanding of the needs and concerns of both end-users and developers.

Policy also affects uncertainty during different implementation stages. This uncertainty affects the worries and enthusiasm of the market variously, thus affecting the effectiveness of the policies themselves. The policy uncertainty is based on the assumption that the timing of the policy's introduction is a major factor in causing uncertainty for the real estate developers (H7). Q16 is designed to elicit information about how the stage at which the policy is implemented affects the real estate developer's concerns, which gives government information that lets it have market concerns in mind as it implements policy at different points in the process.

5.2 INTERVIEW RESULTS

5.2.1 Specific Investment

Table 5.4 Interview results 1

H1 Dividing the transactions of the real estate development (RED) process into smaller established stages helps government to better understand the process and make policies with a more focused emphasis on the different stages of transaction to promote BEE more efficiently.																		
Questions		**Responses**	**Remarks on interviewees**															**overall**
			VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	
Q1	Which are the stages of greatest concern to the developers in the RED process?	*Refer to the findings on the Table "Outline plan of extra work and transaction costs in BEE REDP" indicating the developer's level of concerns in each of the suggested items	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	**100%**
Q2	What are the reasons that make developers willing to invest in new BEE technology without government incentives?	Intangible and tangible factors both take effects. For example, BEE may help if not sell more, it helps sell faster.									√		√		√		√	**26.7%**
		Goodwill for the society, brandings, company image.					√	√	√	√	√			√		√		**46.7%**
		Those that would give immediate effects of the capital return in a short run, say 1-2 years.				√												**6.7%**
		Market demand.	√	√	√					√	√	√						**40%**
	What price difference (% of development cost) would be acceptable?	3% or less			√	√										√	√	**26.7%**
		2-3% or maybe none, it all depends on the developer's different character/ situation.		√			√	√						√				**26.7%**
		5-10%	√						√									**13.3%**
		1-4years									√							**6.7%**
		Within 5%		√							√	√	√		√			**33.3%**
Q3	Uneven emphasis on incentives: What facilities/building elements are more expensive/difficult to be retrofitted, if not installed in the first place?	envelop, curtain walling			√		√	√	√	√	√	√			√	√	√	**66.7%**
		AC (because normally for AC renovation, it will block up the whole floor, thus will cause a loss of rental income and would be more expensive to be retrofitted.)	√	√		√				√	√		√	√				**46.7%**
		Lighting systems		√							√							**13.3%**
		Landscape									√							**6.7%**
	Should they be emphasized in incentives to promote BEE investment?	Yes.	√		√	√	√	√	√		√	√			√	√	√	**73.3%**
	Why?	To help develop and implement new technology.	√		√	√		√	√						√	√	√	**53.3%**
Q4	For developers investing in BEE, what are the different concerns of investing in luxury buildings and in	The luxury building owners are more likely concerned in investing in BEE, because they are better educated and much affordable than the lower price building owners. Social			√		√		√	√		√		√	√	√	√	**60%**

	lower-priced buildings? Why?	consciousness.																
		In lower price buildings, competition is primarily over price.							√									**6.7%**
		For luxury building owners have a higher say, they could drive the market to a higher standard up to their expectation; however, the lower price building owners have little say.			√						√	√			√	√		**33.3%**
		Maintenance cost contain high risk: for the luxury buildings they would be able to afford higher maintenance costs; while for the lower price buildings, it's difficult to afford the maintenance costs for green/BEE features.	√			√		√										**20%**
		Both of these buildings could include green features, of course the luxury building developers could be more generous with his budget; however to the large set of standard provisional buildings, they also could include more green features due to economic of scale. It's a matter of commitment, if one is committed to do it, nothing is impossible.		√						√								**13.3%**
		Most people think green features are luxury.							√									**6.7%**
Q5	There is misplaced benefit between the people who pay and who gain from BEE. To address this problem, would rental/selling-price differences help?	Yes.	√	√	√	√	√		√	√	√	√			√	√	√	**80%**
		Currently in Hong Kong, the rental prices are about the same.		√	√	√					√	√	√	√				**46.7%**
		Green/BEE certification helps consumer to recognize real green buildings so that the developers who produce the genuine BEE can achieve higher profits.								√								**6.7%**
	Any other means help to address the misplaced benefit?	Difficult, because now the trend is more about branding and image, which value more than the GB/BEE.	√	√	√			√	√		√	√		√		√	√	**66.7%**
		Marketing and advertising to make the difference tangible.					√											**6.7%**

Table 5.4 shows the market situation and the developer's business concerns about BEE. These five interview questions are designed mainly to test Hypothesis 1 in one of the three dimensions – specific investment – from a transaction costs perspective. All five questions look at how the effect of specific investment on BEE causes additional transaction costs. (Question 1 focuses on one major part of this research- concerns about TC at different stages of the RED process. Question 1 and related results will be analyzed in a separate section at 5.3).

Observations on the findings: Majority of the interviewees (46.7%) agree that the main reason developers are willing to invest in green technologies in the absence of government incentives lies in "Goodwill for society, brandings, and company image"; 40% of the interviewees think market demand is a major reason that developers invest; another 26.7% respond that "The intangible and tangible factors both have effects, e.g., BEE may help sell faster if not more."

Around half (53.4%) of the interviewees agree that the developers would accept a price difference of less than 3% of investment in BEE without government's support; most of the respondents (86.7%) think the price difference should be below 5%.

Most of the interviewees (73.3%) agree that government incentives should emphasize that those building elements that are more expensive or difficult to be retrofitted should be installed at the outset. The two most noted building elements that interviews regard as easy to make green early are "envelope, curtain walling" (66.7%) and air conditioning (66.7%).

Most of the interviewees agree that luxury buildings are much more likely to include green features: 60% believe this is because the owners of units in luxury buildings are more likely to be more affluent and better educated and with higher levels of social consciousness; another 33.3% think the reason is because these owners have a greater say than lower-income end users and that this will drive the market to a higher standard; 20% suppose that the higher maintenance costs are the concern that drags lower-end owners away from green features, whereas owners in luxury building are more likely to

be able to afford them. One interesting idea (13.3%) is that low-price buildings could also include green features, as long they are included in a large number of standardized buildings to take advantage of economies of scale.

Eighty percent of the interviewees agree that a different rental/selling price will help to motivate BEE investment. However, about half of them confess that currently in Hong Kong, the rental prices are about the same between BEE buildings and non-BEE ones, which makes BEE development much more difficult. The problem of misplaced benefits is difficult to address (agreed by 66.7%), because the public (both the developers and the end-users) values branding and image more than green building.

5.2.2 Frequency

Table 5.5 Interview results 2

H2 There is a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects.																				
Questions		**Responses**	**Remarks on interviewees**																	**overall**
			VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC			
Q6	Will the size of the project affect the developers' concerns about BEE investment?	Economic of scale is applicable here.	√	√	√			√		√	√	√	√							53.3%
		Small to medium size is more likely, not the large size, because they are more concern about their money return. The small it is, the less risk it is.				√			√							√				20%
		The bigger the project is, the more concern the developers have, because it attracts more attention, better for image.								√										6.7%
		The small size project is difficult to do features about energy efficiency. Large amount, size of unit is more concerned.					√													6.7%
		Larger project induces more uncertainty. Hence, they will try well-tested green features only to large project.	√	√				√	√		√	√		√	√	√	√			66.7%
Q7	Will the size of the RED company affect the developers' concern about BEE investment?	Yes.	√	√	√	√	√	√	√	√		√	√		√	√	√			86.7%
		Large company with small project.				√			√							√				20%
		Large company has incentive to build brand name for long term development.		√	√				√		√	√			√	√	√			53.3%
H3 There is a positive relationship between the frequency of BEE investments and the transaction costs incurred in developing BEE projects.[25]																				
Q8	How does the frequency (e.g., regular, occasional, or at one-time) of developers' BEE investments affect their concerns about BEE investment?	The more frequent the BEE investment is, the less concerns the developers have. (by experience)	√		√		√	√	√	√	√	√	√		√	√	√			80%
		The more frequent the BEE investment is, the more concerns the developers have. (The more you provide/ consume certain type of product, the more concern you will have as a regular business that how much discount/ rewards you will have by doing so.)				√						√		√	√	√				33.3%
		Uncertainty is one reason that stops the frequency of BEE investment to accumulate the volume of the transaction.		√							√	√	√							26.7%
Q9	Would the developers' concerns change if they invested in BEE projects more frequently? Why?	Yes. The familiarity of the policy, technology, networks with the relevant stakeholders during the RED process is improved with the learning curve.	√		√	√	√	√	√	√	√	√	√	√	√	√	√			93.3%
		Energy retrofits in existing buildings are preferable to the developers because it requires lower capital and shorter return. And they can do these projects more frequently.	√	√				√	√		√	√				√	√			53.3%

[25] There are a few concerns here: 1. The transaction costs will increase along with the frequency of transactions. However, due to economies of scale, the transaction costs per transaction will decrease accordingly. 2. Concerns about BEE investments will differ among regular investors and occasional ones. One possibility is that occasional investors just invest once and do not worry too much about the consequences of the investment; their expectations of government incentives and returns may not be as high as those of regular investors.

This table 5.5 illuminates the relationship between the market situation and the developers' business concerns about BEE. These four interview questions are designed mainly to test Hypotheses H2 and H3 in one of the three dimensions – frequency. All four questions concern the extent to which the frequency of investments in BEE causes additional transaction costs.

Observations on the findings:

The size of the project affects the concerns of developers. The statement "Larger projects induce more uncertainty, so only well-tested green features will be included in the large projects," is agreed with by 66.7% of interviewees, and 53.3% agree that "Economies of scale are applicable to BEE projects."

"The size of the real estate development company affects the developers' concerns about BEE investment," is agreed with by 86.7% of the interviewees, whereas 53.3% believe that "A large company has the incentive to build its brand name by investing in BEE for long-term development, and only three out of the fifteen interviewees (20%) think that "A large company with a small project" is more likely to integrate BEE features.

Eighty percent of the interviewees agree that "The more frequent the BEE investment, the fewer the concerns of the developers." However, another 33.3% of the respondents believe the opposite. Their argument is that "The more one provides/consumes a certain type of product, the more concerns one may have about how much greater the effect will be of doing more.

The majority (93.3%) of the interviewees believe that the developers' concern will change if they invest in BEE projects more frequently, because "The familiarity of the policy, technology, and networks with the relevant stakeholders improves with the learning curve." More than half of the respondents agree that in Hong Kong, "Developers prefer energy retrofits to existing buildings, because they require lower capital and provide a faster return, and they can do these kinds of projects more frequently."

5.2.3 Uncertainty

5.2.3.1 Economic uncertainty

Table 5.6 Economic uncertainty

H4 The economic context (upturn or downturn economic transition) affects the concerns of the real estate developers about BEE investment.																		
Questions		**Responses**	**Remarks on interviewees**															**overall**
			VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	
Q10	At times of economic transition, what new challenges or opportunities arise for investments in BEE?	It depends on the planning and priority and value judgment of the corporation and individual decision-maker.		√							√	√	√		√		√	**40%**
		When product harder to place in the market (less demand, more competition), green building can be competitive advantage which is not necessary in times when easy to sell. So more incentive to go in green building								√								**6.7%**
		Do more, faster and put more resources in the economic upturn.						√	√		√						√	**26.7%**
		Limited budget in the downturn.	√			√												**13.3%**
		More challenges than opportunity in the downturn.			√			√							√			**20%**
	How do shifts in the economy change the developers' major concerns (neutral, positive, or negative) and in which aspects?	Like in this economic downturn in Hong Kong, the developers are more willing to do the energy retrofits, because it's much quicker to get the capital return back. **(neutral)**	√		√													**13.3%**
		When it's economic downturn, the developers will be more conservative/ reluctant to any innovative project including green features due to limited budget; while in its upturn, they will be more likely willing to invest in BEE.				√	√	√							√			**26.7%**
		Economic downturn is a better chance to further the green/ BEE development, because people expect changes; however, in the economic upturn, everything is prosperous, and why would the developers change their regular earning formula of their investment (MT). Also, it also because if the government takes the opportunity in the economic downturn to shout loud to promote BEE/ green, it is more an opportunity than a challenge to further its development (SY).		√					√		√	√	√	√		√	√	**53.3%**
Q11	When the direction of the economy shifts, how might developers integrate green features into original investments to increase market	The previous economic downturns maybe different from the current one, because the green movement is not as heat-up as it is now. Therefore, it more depends on the individual developer and its own capital capacity and business strategy to integrate green features into the practice.	√		√			√										**20%**

	competitiveness?	Need more government incentives, moneywise, to promote BEE to the developer; education wise, to the whole public.				√					√	√	√	√		√	√	**46.7%**
		Both the government and the developers should have long term views and will, regarding BEE, even in economic downturn.					√											**6.7%**
		At the economic down-turn, the developer would mainly to improve the "green" image to add to their brand-name, but the end result is not very significant. Because it attract mainly the user-buyers, not the speculators. The developers want the speculators for profits more than the user-buyers.		√					√		√	√	√	√	√	√	√	**60%**
H5 Changes in economic conditions (upturns and downturns) call for the attention of government to adjust BEE policies as necessary to seize BEE development opportunities.																		
Q12	What role should government play in BEE promotion (more intervention or less intervention in a recessionary economy)?	Basically, during the economic up-turn, government incentives or promotion are less effective than the down-turn, because the property sells well and the buyers are less concern about green features. During the economic downturn, government incentives are more important, because the developers are more reluctant to invest in green and people who buy also need to be more assured by the benefits from green incentives.	√	√	√			√	√		√	√			√	√	√	**66.7%**
		During economic upturn, but steady and gentle growth would be the best time to developers to invest in BEE, and the best time for the government to promote BEE, too.				√												**6.7%**
Q13	What BEE promotions or incentive could government introduce in times of economic change that would be less upsetting to the market players' normal activities?	Basically, during the economic up-turn, government incentives or promotion are less effective than the down-turn, because the property sells well and the buyers are less concern about green features. During the economic downturn, government incentives are more important, because the developers are more reluctant to invest in green and people who buy also need to be more assured by the benefits from green incentives.		√	√			√	√		√	√	√			√	√	**60%**

Observations on the findings:

This table 5.6 illuminates the market situation and developers' business concerns and is one of three tables regarding the uncertainty aspect of transaction costs. Four interview questions are designed to test H4 and H5 as to one of the three categories of uncertainty – economic uncertainty. All four questions look at how economic uncertainty affects BEE development by causing additional transaction costs.

The respondents had a wide ranges of viewpoints about new challenges and opportunities at times of changing economic conditions: 40% believe that "It all depends on the planning, priorities, and value judgments of the corporation and individual decision-makers," 20% think it is "More a challenge than an opportunity in an economic downturn," 26.7% believe that it is more a challenge "in an economic upturn" when developers need to "do more, faster, and with greater resources," and 13.3% respond that "Limited budgets in a downturn" will affect BEE development.

More than half of the interviewees (53.3%) agree that, "An economic downturn is a better chance to further BEE development, because people expect change; whereas, in economic upturns, everything is prosperous, developers have little reason to change their regular earnings formula to try something new and risky." Hence, "If the government takes the opportunity of the economic downturn to promote BEE vigorously, it is recognized that conditions present more of an opportunity than a challenge." However, 26.7% take the opposite viewpoint, "In an economic downturn, developers will be more conservative and reluctant to take on any innovative project, including green features, due to limited budgets; in an upturn, it is more likely that developers will be willing to invest in BEE." A further 13.3% take a view based on a local example: "In this economic downturn in Hong Kong, the developers are more willing to do energy retrofits, because it is much quicker to get the capital return back."

Regarding Q11, most of the interviewees focus on the current "economic downturn." Sixty percent respond that "In the economic downturn, developers would want improve their reputation for being green to add to their brand name, but the end result would

not be very significant, because it attracts mainly the user-buyers, not the speculators. The developers want the speculators for profits more than the user-buyers." In addition, 46.7% think that "Both the government and the developers should have long-term views regarding BEE and will, even in economic downturns." However, 20% express a more conservative view; they think "This economic downturn may be different from earlier ones, because the green movement was not as popular as it is now. Therefore, integrating green features will depend more on the individual developer, its capital capacity, and its business strategy."

Regarding the role that government plays during times of economic change, most people agree that "Basically, during an economic upturn, government incentives and promotion of BEE are less effective than in a downturn, because the property sells well and the buyers are less concerned about green features. During economic downturns, government incentives are more important, because the developers are more reluctant to invest in green technologies, and people who buy also need to be more assured of the benefits." There is a striking statement by one interviewee, though, who said, "Steady and gentle growth would be the best time for developers to invest in BEE and the best time for the government to promote BEE, too."

5.2.3.2 Market uncertainties

Table 5.7 Interview results 3

H6 The end-users' variable expectations about BEE increase market uncertainty to the developers (e.g. ., they may misinterpret a focused group as the end-users of their final products.)																		
Questions		**Responses**	**Remarks on interviewees**															**overall**
			VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	
Q14	Occupants' behavioral differences may lead developers to produce different BEE/GB at different performance levels. What is your view?	In Hong Kong, we are going to have (not yet) a measurement for the building whether it's a good performance or not. The trend is changing, Hong Kong now is going to have carbon audit, which will be an annual report of the carbon performance of each building/ household. This will be very good in transforming the occupant's behavior. It's always about the awareness and transparency. In the future, Hong Kong will have the carbon audit, people can understand and compare the carbon performance, and by that information and transparency, people can compare and shape their behavior.	√	√	√				√	√	√	√			√	√	√	**66.7%**
		Less than 20% (10-20%) of the influence by the occupant's behavior.				√						√						**13.3%**
		Still the cost is the major concern.		√				√			√	√	√	√		√	√	**53.3%**
Q15	Will concerns about social classes (different education levels, experiences, financial ability to enjoy the benefits of BEE) affect the developers' concern about BEE investment?	Yes. The rich people in higher social classes will appreciate the benefits of BEE better than the low income people, which attract the developers to invest in BEE for high price buildings.				√		√		√	√	√		√		√	√	**53.3%**
		The higher educated class will appreciate the BEE better, which would contribute towards a better environment.	√	√	√				√				√		√	√	√	**53.3%**

The table 5.7 shows the market situation and the developers' concerns about BEE, and is one of three tables regarding the uncertainty aspect of transaction costs. Two interview questions are designed to test Hypothesis 6 in one of the three categories of uncertainty – market uncertainty, as a transaction cost. Both questions look at how market uncertainty affects BEE development by causing more transaction costs.

Observations on the findings:

Regarding the occupants' behavior, 66.7% of the interviewees believe that "In Hong Kong, we are going to have (not yet) a measurement of the level of a building's green performance. The trend is changing, Hong Kong now is going to have carbon audit, which will be an annual report of the carbon performance of each building/household. This will be very good in transforming the occupants' behavior. It's always about awareness and transparency. In the future, Hong Kong will have the carbon audit, people can understand and compare carbon performance and use that information and transparency to compare and shape their behavior." Around half (53.3%) agree that "Cost is still the major concern to the occupants".

Regarding how social class might affect the developers' concerns, two equally weighted views have been found: "The rich people in higher social classes will appreciate the benefits of BEE more than lower-income people, and this will attract investments in BEE for high price buildings;" "The more-educated will appreciate BEE more, and this which will contribute towards a better environment." These responses suggest that the developers and government incentives will target those with more money and education.

5.2.3.3 Policy uncertainties

Table 5.8 Interview results 4

H7 The earlier the stage of BEE policy implementation, the greater the real estate developers' concerns about transaction costs.																		
Questions		**Responses**	**Remarks on interviewees**															**overall**
			VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	
Q16	Would a new incentive and a currently mature incentive affect the developers' concerns about BEE differently? In other words, encountering BEE incentives, would the developers have more concerns during the early or later stage of the implementation of the incentive? How are they different?	Based on the international experience/ practice, the government will first take part in the new movement by integrating all their projects with the new features as pilot projects (demonstration projects) and share the experience with the market. After a certain period of time/ few years, they could find out all these worries, they will then mandate the polity to the market.	√	√	√				√	√	√	√			√	√	√	**66.7%**
		The developer will welcome early incentives in early stages. And established schemes of incentives are more easily understandable and acceptable.					√											**6.7%**
		Yes. The earlier stage it is, the more challenge will be, the latter stage it is, it becomes more like a formula.				√												**6.7%**
		For a new incentive, the most concern to the market is if it's stable and long-lasting. Therefore, the more established the less concern.		√				√			√	√	√	√			√	**46.7%**
		The later stage, because the developers would like to see what happened to the others.					√											**6.7%**
		More concerns during the early stage because more uncertainty.	√	√	√			√	√		√	√	√	√		√	√	**73.3%**

This table sheds light on market conditions and how they affect developers' concerns about BEE, and is one of the three tables regarding uncertainty as a transaction cost. One interview question is designed to test Hypothesis 7, regarding policy uncertainty. All four questions look into how policy uncertainty affects BEE development by creating additional transaction costs. This question solicits the opinions of the interviewees about the developers' concerns regarding the different stages of BEE policy implementation.

Observations on the findings:

The majority (73.3%) think "More concerns arise during the early stages because there is more uncertainty then." Another large group (66.7%), when asked what the government could do better, said that "Given international experience, the government will first take part in the new movement by initiating all their projects involving new BEE features as pilot or demonstration projects and share the experiences with the market. After a certain period of time (some said a few years), they can investigate the concerns that arose and then mandate the policy." In general, the majority agree that "For a new incentive, the greatest concern to the market is if it is stable and long-lasting. Therefore, the earlier the stage of development, the greater the challenge, and the more established the practice, the less the concern."

5.3 CONSIDERING TRANSACTION COSTS CAUSED BY BEE AT DIFFERENT STAGES OF THE REAL ESTATE DEVELOPMENT (RED) PROCESS

Table 3.3, in Chapter 3, shows the extra work and related transaction costs in BEE real estate development. Based on those possible extra tasks involved at different stages of the RED process, key senior professionals of RE development companies and their representative were interviewed to seek their views of the significance of TC considerations for each of the extra tasks. Table 5 summarizes the views of the interviewees.

Instructions to Interviewee:

Focusing on the column "Extra Tasks to be done (by developer for BEE)", indicate, for each item:

S (√): Standard extra considerations that could easily be covered by an extra % expenses/fee (e.g., pay a specialist consultant to do the work);

U (√√): Uncertainty (in terms of time, cost, government requirements, sales, etc.);

V (√√√): High uncertainty (in terms of time, cost, government requirements, sales, etc.); and

X (0): Not applicable or so low that it can be ignored.

Profiles of the interviewees:

1. VC: (Executive Director of E&M Engineering)
2. MT: (Executive Director of one of the top developers)
3. KS: (Sustainable development director for a leading architectural firm)
4. FC:: (Associate Director of a world-class architectural firm)
5. PE: (Director of one of the top 2 QS firms)
6. SK: (Director, Campus Development of a Hong Kong university)
7. JP: (senior officer, Environmental Protection Department)
8. SM: (Director of a medium size QS firm)
9. SY: (Director, one of the top developers)
10. Q: (Director of one of the top developers)
11. NB: (Chairman of a leading property services company)
12. TM: (Director of an international property investment company)
13. WC: (Director, Science Park)
14. KC: (Managing Director of a surveyor company Ltd., and past president of the Professional Green Building Council)
15. EC: (Architect, and Honorary Secretary of the Professional Green Building Council)

Table 5.9 Extra Tasks to be done in REDP- Briefing stage

	Extra Tasks by BEE	VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	Highest frequency	Overall grading	Remarks
Briefing stage	1. Set up extra organization for briefing in relating with BEE.	U	S	U	S	S	X	S	X	X	S	/	/	S	S	S	S (61.5%)	S	Consistently standard risk
	2. Consider extra BEE related market and policy requirements.	U	U	U	U	S	X	S	U	S	U	/	/	V	S	U	U (53.8%)	U	Consistently High risk
	3. Appoint special architect and involve special stakeholders in relating to BEE.	U	S	U	S	S	S	S	S	S	S	/	/	S	S	S	S (84.6%)	S	Very consistently standard risk
	4. Need JV or Co-developer for such special project?	U	X	X	X	X	X	X	X	X	X	/	/	U	X	X	X (84.6%)	X	Very consistently not applicable
	5. Carry out extra studies of market requirements and expectation on BEE (considering local community need/supply/competitiveness).	V	U	U	U	U	S	S	U	S	U	/	/	U	S	U	U (61.5%)	U	Very consistently High risk
	6. Extra BEE planning, design, and cost, etc., as necessary to reach decisions.	V	U	S	S	U	S	S	S	S	S	/	/	U	S	U	S (61.5%)	S	consistently standard risk
	7. Extra effort to identify potential users.	V	X	U	U	U	U	S	U	S	U	/	/	U	S	U	U (61.5%)	U	consistently High risk
	8. Study the extra financial risk.	V	X	S	U	U	S	S	X	X	S	/	/	V	S	S	S (46.1%) X (23%)	S	Diverse opinion but tends to be standard risk
	9. Consideration of extra legal liability risk of the BEE product.	U	X	V	S	V	S	S	V	X	U	/	/	U	S	V	V (30.7%) S (30.7%)	V	Very diverse opinion but ,tends to be high and Very High risk
	10. More careful review of available information on BEE products.	V	U	U	S	U	U	S	U	S	U	/	/	U	S	U	U (61.5%)	U	Consistently High risk

Sketch plan stage and working drawing stage

	Extra Tasks by BEE	VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	Highest frequency	Overall grading	Remarks
Sketch Plans stage	11. Special User Requirement study	V	U	S	U	S	S	S	S	S	X	/	/	S	S	S	S (61.5%)	S	Consistently standard risk
	12. Explore special technical solutions.	V	U	U	S	U	S	S	U	X	U	/	/	U	S	U	U (53.8%)	U	Consistently High risk
	13. Special concept/design that need negotiation with government for approval.	V	V	V	S	U	U	V	U	S	V	/	/	V	U	V	S (84.6%)	S	Very consistently standard risk
	14. Design leading to non-efficiency use of floor area.	V	S	U	S	U	U	V	V	X	U	/	/	S	U	U	X (84.6%)	X	Very consistently not applicable
	15. Special cost study for using new design features.	V	U	S	S	S	U	S	U	X	S	/	/	U	S	S	U (61.5%)	U	Very consistently High risk
Working drawing stage	16. Financial negotiations for new design feature (Mortgage/Loan/construction loan).	X	X	U	S	S	X	X	X	X	X	/	/	V	S	X	S (61.5%)	S	consistently standard risk
	17. Search for a list of contractors with special expertise.	V	U	V	S	U	S	S	S	X	S	/	/	U	S	S	U (61.5%)	U	consistently High risk
	18. Limited no. of contractors available that reduce competition.	V	X	V	U	U	U	S	U	X	S	/	/	U	S	U	S (46.1%) X (23%)	S	Diverse opinion but tends to be standard risk

Site operation stage

	Extra Tasks by BEE	VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	Highest frequency	Overall grading	Remarks
Site operation stage	19. Extra effort to brief all project personnel of the project requirement and procedure for administer the project.	V	S	U	S	S	S	S	S	X	S	/	/	S	S	S	S (76.9%)	S	Very Consistently standard risk
	20. Special promotion strategy and materials for Marketing and Leasing.	V	U	U	U	U	U	S	S	S	U	/	/	V	S	V	U (46.1%) V (23%)	U	diverse opinion , tends to be High risk
	21. Additional consideration of tenant for BEE products.	V	U	U	S	U	S	S	S	S	S	/	/	U	S	U	S (54.5%) U (38.5%)	S/U	Very diverse opinion between High and Standard risk
	22. Extra requirement on Testing and Commissioning of service installations to obtain Green Labeling etc.	V	U	S	U	U	S	U	U	X	V	/	/	S	S	U	U (46.1%) S (30.7%)	U	diverse opinion , tends to be High risk
	23. Special effort to prepare maintenance manual	V	U	S	S	S	S	V	U	X	U	/	/	S	S	S	S (53.8%)	S	diverse opinion but tends to be standard risk
	24. Extra fee for certificates involving Green items	V	S	S	S	S	U	S	S	X	S	/	/	U	S	S	S (69.2%)	S	Very Consistently standard risk

Feedback and maintenance stage

	Extra Tasks by BEE	VC	MT	KS	FC	Pe	SK	JP	Sm	SY	Q	NB	TM	WC	KC	EC	Highest frequency	Overall grading	Remarks
Feedback & Maintenance stage	25. Special property skill requirement for Property management plan	V	U	U	S	U	S	V	S	S	S	/	/	U	U	S	U (38.5%) S (46.2%)	U/S	Very diverse opinion but , tends to be between high risk and Standard risk
	26. Special strategy and materials for overall marketing or leasing of the completed green/ BEE building.	V	U	S	U	U	S	X	S	S	V	/	/	V	U	V	U (31%) V (31%) S (31%)	U/V	Very Diverse opinion but mostly between High and Very High risk
	27. To keep building running effectively and under good repair	V	S	S	S	U	S	X	S	X	S	/	/	U	S	U	S (53.8%)	S	Diverse opinion but tends to be standard risk
	28. Developer's Key Actions: Set up and manage ownership entity	X	X	S	S	S	U	S	S	X	X	/	/	X	X	X	X (53.8%) S ((38.5%)	X	Diverse opinion, but mostly of not applicable
	29. More special green items to be taken care of for Property improvement	V	S	S	S	S	S	S	S	S	S	/	/	U	S	U	S (76.9%)	S	Very consistently standard risk
	30. Easy to sell or rent out Property (Involve more guarantee certificates?)	U	S	S	S	U	U	V	S	X	S	/	/	U	U	V	S (38.5%) U (38.5%)	U	Very diverse opinion but tends to be of High risk

5.3.1 Briefing stage

At the briefing stage, interviewees were asked about ten extra tasks, identified from the literature review. Four are regarded as representing normal levels of risk (S) at various levels of development and could be covered by lump sum money. Developers are not too concerned about these. These four tasks, listed here from the most to the least acceptable, are: No. 3. Appoint a special architect and involve special stakeholders in relation to BEE" (S: 84.6%)"; No. 1. Set up extra organizational structures for briefings in relation to BEE" (S: 61.5%); No. 6. "Extra BEE planning, design, and cost, etc., as necessary to reach decisions" (S: 61.5%); and No. 8. Study the extra financial risk" (S: 46.1%).

Four tasks are regarded as involving uncertainty (U), which means there is no standardized practice in the market for the developers to refer to regarding the use of lump sum without worrying about risk. These tasks are normally not standardized and cannot be predicted. These four tasks, listed from the most to the least acceptable, are: No.5. Carry out extra studies of market requirements and expectations about BEE (considering local community need/supply/competitiveness)" (U: 61.5%); No.7. Extra effort to identify potential users" (U: 61.5%); No. 10. More careful review of available information on BEE products" (U: 61.5%); and "2. Consider extra BEE-related market and policy requirements" (U: 53.8%). Here, the higher rate means that more people agree that the item should be rated as U.

One task, No.9: The consideration of extra legal liability risks for the BEE product" (V: 30.7%; S: 30.7%), is rated equally as "very uncertain" and "standard". Opinions about this task are very diverse, and in the author's judgment, it appears to be of great uncertainty and very high risk (V). Another task, No. 4: "Need JV or co-developer for a special project?" is consistently considered to be not applicable as a BEE special task.

5.3.2 Sketch-plan stage

Five tasks were confirmed as extra work at the sketch-plan stage. Two are considered to be of normal risk levels. In decreasing order, these are: No. 13. Special concepts/designs that need negotiation with government for approval" (S: 84.6%), and No.11. Special User Requirement study" (S: 61.5%). Both of these tasks are generally considered to be of standard risk that will not cause extra concern besides the lump sum money input. No.15. Special cost study for using new design features" (U: 61.5%), and "Explore special technical solutions" (U: 53.8%) are the two tasks among the five that are consistently rated to be of high risk to the developers, and which cause high concern in their decision-making about BEE investment. No.14. Design leading to non-efficiency use of floor area" (X: 84.6%) is generally considered not to be an extra task for BEE during the sketch-plan stage.

5.3.3 Working-drawing stage

Three tasks are proposed and confirmed during this stage. No.16. Financial negotiations for new design feature (Mortgage/Loan/Construction loan)" is rated consistently as of standard risk (S: 61.5%). Another S-rated task is No. 18. Limited number of contractors available, which reduces competition" (S: 46.1%; X: 23%), which shows more diverse opinions about tasks with a higher tendency to be considered standard risk. No.17. Search for a list of contractors with special expertise" (U: 61.5%) is consistently considered to be of high risk and concern to developers.

5.3.4 Site-operation stage

Six extra tasks for BEE were selected and confirmed by the interviewees. Three of these are rated S (in decreasing order): No.19. Extra effort to brief all project personnel of the project requirements and procedures for administering the project" (S: 76.9%); No.24. Extra fees for certificates involving Green items" (S: 69.2%); and "Special efforts to prepare maintenance manuals" (S: 53.8%). These three are all rated as being of standard risk that lump sum money can cover without too much concern. The two tasks rated U are: No.20. Special promotion strategy and materials for Marketing and Leasing" (U: 46.1%; V: 23%), and No.22. Extra requirements of testing and commissioning of

service installations to obtain green labeling" (U: 46.1%; S: 30.7%), both of which elicit highly diverse opinions but are high risk. The task: No.21. Additional consideration of tenants for BEE products" (S: 54.5%; U: 38.5%) is rated with very diverse opinions between high and standard risk.

5.3.5 Feedback and maintenance stage

There are six BEE extra tasks at this stage. Two of them are generally agreed to be of standard risk (S). By decreasing order of rating, these are: No.29. More special green items to be taken care of for property improvement" (S: 76.9%) and No.27. To keep buildings running effectively and in good repair" (S: 53.8%).

The other two extra tasks elicited diverse opinions. No.25. Special property skills requirement for Property management plan" (U: 38.5%; S: 46.2%) is deemed to be between high risk and standard risk and No.26. Special strategy and materials for overall marketing or leasing of the completed green/BEE building" (U: 31%; V: 31%; S: 31%) attracted split opinions, but is mainly judged as a high or very high risk. The author judges No.30. Easy to sell or rent out property (Involving more guarantee certificates?)" (S: 38.5%; U: 38.5%) as being of high risk. Finally, the task: No.28. Developer's Key Actions: Setting up and managing ownership entity" (X: 53.8%; S: 38.5%) is generally considered by the respondents to be not applicable.

5.4 QUESTIONNAIRE SURVEYS ON BUSINESS REASONS FOR INVESTING IN GB MARKET

The benefits that BEE could bring to society are known, and improving energy consumption in buildings means that financial savings should act as business incentives for investors to enter the BG market. In Hong Kong, buildings consume over half of all energy and about 89% of electricity, mainly and substantially for air-conditioning, which is the source of roughly 17% of all of Hong Kong's greenhouse gas emissions (CE, 2008; EB, 2008). Singapore Power's Annual Report for 1999 (quoted by Lee, 2001) shows that electricity consumption in buildings, excluding the industrial sector, represents 57% of the energy used. The residential portion of electricity consumption is 20%. Electricity

consumption by office buildings is responsible for 12% of the overall non-manufacturing sector's consumption (Lee, 2001). More recent data quoted by Lee and Rajagopalan (2008) show the use of electricity in buildings to constitute around 16% of Singapore's energy demand. They hold that establishing energy efficiency measures is one of the key missions to ensure that the economy is sustainable.

The author has the opportunity to meet Dr. Matthias Krups, the Chairman and CEO of the BCI Group, who provided the BCI data source, and Mr. Peter Rolshoven, who helped on clarifying the data. The main objective of the survey is more related to the overall market environment for green building. However, the author has gone through the whole set of the raw data of the survey and find at least three questions, namely: business reasons, market obstacles and favorable factors, whose analysis result could provide the potential to corroborate some of the objectives of the PhD study. Hence, data analysis results are used to contribute to the triangulation analysis for the overall findings of the PhD.

Questionnaires surveys of building designers in Hong Kong and Singapore

The questionnaires were designed to solicit perceptions from building designers on the economic issues of green building and the energy efficiency market in Hong Kong and Singapore. The literature review (refer to 3.5.4, pp68-70) identifies the following research questions.

- **What are the major business reasons that drive the GB market?**
- **What are the major obstacles to GB?**
- **What are the major favorable factors that further GB development?**

These questions are meant to explore the market functions and problems of business opportunities. For the business world, the basic reasons for entering a particular market must be economic. Additional reasons, in different forms, may also be directed toward economic gain. To address the third research question, the following three hypotheses

are proposed with the assumption that cost is the primary consideration for investing in a new BG market.

Hypothesis B1: Cost concerns are the major business reasons that make the BG market attractive for investment.

Hypothesis B2: Cost concerns are the major obstacles that hinder investors from entering the GB market.

Hypothesis B3: Cost concerns are the major factors that help to advance GB development.

The specific forms suggested by the literature can be summarized as follows:

"Business reasons that drive the market" include lower operating costs, higher building values, lower lifetime costs, higher returns on investment (ROI), helping to transform the market, increased staff productivity and retention, enhanced marketability, and reduced liability and risk.

"Market obstacles" include perceived higher upfront costs, lack of education, lack of awareness about such different accounting methods as capital costs and operating costs, no coordination and consistency in rating tools and standards, unrecognizable eco-labeling for products and materials, no fiscal incentives from government, and lack of research and case studies.

"Factors that attract business" include rising energy costs, the superior performance of GB products, client demand, industry rating systems such as LEED, Green Star, and Green Mark, government regulations including building codes, the lower lifecycle costs of GB, worsening environmental conditions, the competitive advantages of green projects, higher tenant satisfaction and productivity in green buildings, increased education about GB, and better availability and greater affordability of GB technology.

These hypotheses will be tested with data collected from a survey of building designers in Hong Kong and Singapore. The research method and target sampling are presented in the Research Methodology section of Chapter 2.

5.5 DATA ANALYSIS AND FINDINGS

5.5.1 Analysis of respondents and responses

One of the questions in the questionnaire – "business reasons" – was extracted to assess the agreement of the survey responses and the association between the rankings of Hong Kong and Singapore. The Kendall Coefficient of Concordance W to test the Agreement within the rankings, so that there is consistency between the respondents on their answers to the questionnaires. And Mann-Whitney U test to ensure the association between Hong Kong and Singapore, to make sure the samples chosen could be grouped and compared to serve the research purpose. The data were analyzed with the aid of a Microsoft Excel spreadsheet and the Statistical Package for Social Sciences (SPSS) computer software (Kirkpatrick & Feeney, 2001).

1. Agreement within groups

The Kendall Coefficient of Concordance W

The Kendall Coefficient of Concordance W has been calculated to evaluate the association among the scaled answers (Siegel & Castellan, 1988). W is used for ascertaining the overall agreement among k sets of rankings. It is a coefficient index to represent the degree and divergence of the actual agreement among the sets of rankings. Kendall's Coefficient, W, ranges between 0 (no agreement) and 1 (complete agreement).

The value of *W* is computed as:

$$W = \frac{\sum_{i=1}^{N} \left(R_i * - R *\right)^2}{N\left(N^2 - 1\right) \big/ 12}$$

Where

K = the number of sets of rankings, which in this study is the number of valid responses,

N = the number of objects being ranked, which in this study is the eight proposed business reasons,

R_i* = the average of the ranks assigned to the *i*th object, and

*R** = the average (or the grand mean) of the ranks assigned across all objects.

The *Coefficients of Concordance W* as W_{HK} and $W_{Sgp,}$ are 0.28 and 0.16 respectively. Because N＞7, and given the large sample size (＞20), the significance of an observed *W* is determined by referring to the approximate distribution of *chi square* values with *N* = 1 degree of freedom (Siegel & Castellan, 1998).

$X^2 = k\,(N\text{-}1)\,W$

With X^2_{HK}=201.88 and X^2_{Sgp}=86.24, *df*= 7, the probability is less than p＜.001. This indicates a strong consensus among the respondents in both Hong Kong and Singapore as to which business reasons drive GB.

2. Association between Hong Kong and Singapore

Mann-Whitney U test

To determine the degree of association of rankings of different business reasons from the viewpoint of building designers in Hong Kong and Singapore (rankings shown in Table 1), a Mann-Whitney U test is conducted. The Mann-Whitney U test is used to discern any statistically significant difference between two independent groups on a continuous measure. It is an alternative to the t-test for independent samples, in that no assumption on data distribution is required. It converts the scores for the continuous variables to ranks across the two groups, then evaluates whether the ranks for the two groups differ significantly.

Table 5.10 The ranking result on "business reasons"
（1 = "Hong Kong", 2 = "Singapore"）

Business reasons	Location	N	Mean Rank	Sum of Ranks
BR1 - Lower operation costs	1	103	84.71	8725.50
	2	77	98.24	7564.50
BR2 - Higher building value	1	103	86.00	8858.00
	2	77	96.52	7432.00
BR3 - Lower lifetime cost	1	103	88.66	9132.00
	2	77	92.96	7158.00
BR4 - Higher return on investment (ROI)	1	103	93.27	9607.00
	2	77	86.79	6683.00
BR5 - Help to transform the market	1	103	88.90	9156.50

	2	77	92.64	7133.50
BR6 - Increase staff productivity and retention	1	103	90.89	9362.00
	2	77	89.97	6928.00
BR7 - Enhanced marketability	1	103	88.02	9066.00
	2	77	93.82	7224.00
BR8 - Reduced liability and risk	1	103	99.63	10262.00
	2	77	78.29	6028.00

Table 5.11 Mann-Whitney U-test result

Test Statistics(a)

	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8
Mann-Whitney U	3369.500	3502.000	3776.000	3680.000	3800.500	3925.000	3710.000	3025.000
Wilcoxon W	8725.500	8858.000	9132.000	6683.000	9156.500	6928.000	9066.000	6028.000
Z	-1.814	-1.360	-.558	-.834	-.482	-.119	-.748	-2.828
Asymp. Sig. (2-tailed)	.070	.174	.577	.404	.630	.905	.454	.005

a Grouping Variable: location （1= “Hong Kong”, 2= “Singapore”）

From the U-test result in Table 2, the z values for each of the eight business reasons are: -1.814, -1.360, -.558, -.834, -.482, -.119, -.748, and -2.828, with a significance level of p= .070, .174, .577, .404, .630, .905, .454, and .005, respectively. The probability value (p) for the first seven BRs is higher than .05, and only the last is lower, at .005. Hence, there is no statistically significant difference in seven of the eight business-reason rankings of Hong Kong and Singapore respondents. This shows good overall agreement between respondents from Hong Kong and Singapore.

The author only chooses “business reasons” to test the sample, which could also be done with “obstacles” or “favorable factors”. It is a random selection to test the sample. Since the questionnaire survey is conducted with the same group of respondents, in other words, the sample is set, to test any one of the question (business reasons/ obstacles/ favorable factor) will sufficient enough and takes the same effect to validate the selection of the sample.

5.5.2 Findings

5.5.2.1 Findings on "Business Reasons"

An overview is obtained by calculating the mean, median, and modal values in Table 3.4. These measures of central tendency are used to assess the homogenous or heterogeneous nature of the collected data (Bernard, 2000).

Table 5.12 Descriptive Statistics - Hong Kong

Business reasons (1)	Mean (2)	Median (3)	Mode (4)	Std. Deviation (5)	Variance (6)
Lower operation costs	2.32	2	1	1.781	3.170
Higher building value	3.29	3	4	1.791	3.208
Lower lifetime cost	3.64	3	2	2.009	4.036
Higher return on investment (ROI)	4.52	4	3	2.052	4.213
Help to transform the market	5.07	5	6	1.977	3.907
Increase staff productivity and retention	6.07	6	7	1.705	2.907
Enhanced marketability	4.32	4	5	1.848	3.416
Reduced liability and risk	6.75	7	8	1.625	2.642

Table 5.13 Descriptive Statistics - Singapore

Business reasons (1)	Mean (2)	Median (3)	Mode (4)	Std. Deviation (5)	Variance (6)
Lower operation costs	2.87	2	1	2.097	4.399
Higher building value	3.77	4	4	2.083	4.339
Lower lifetime cost	3.73	3	2	1.811	3.280
Higher return on investment (ROI)	4.25	4	5	2.122	4.504
Help to transform the market	5.13	6	7	2.308	5.325
Increase staff productivity and retention	5.94	6	8	1.976	3.904
Enhanced marketability	4.51	5	4	1.937	3.753
Reduced liability and risk	5.87	6	8	2.179	4.746

Analysis of the data shows relatively close values for the means, medians, and modes, with low variances and standard deviations. This confirms the acceptable quality and homogeneity of the collected data and also a reasonably low degree of dispersion, resulting in reliable findings.

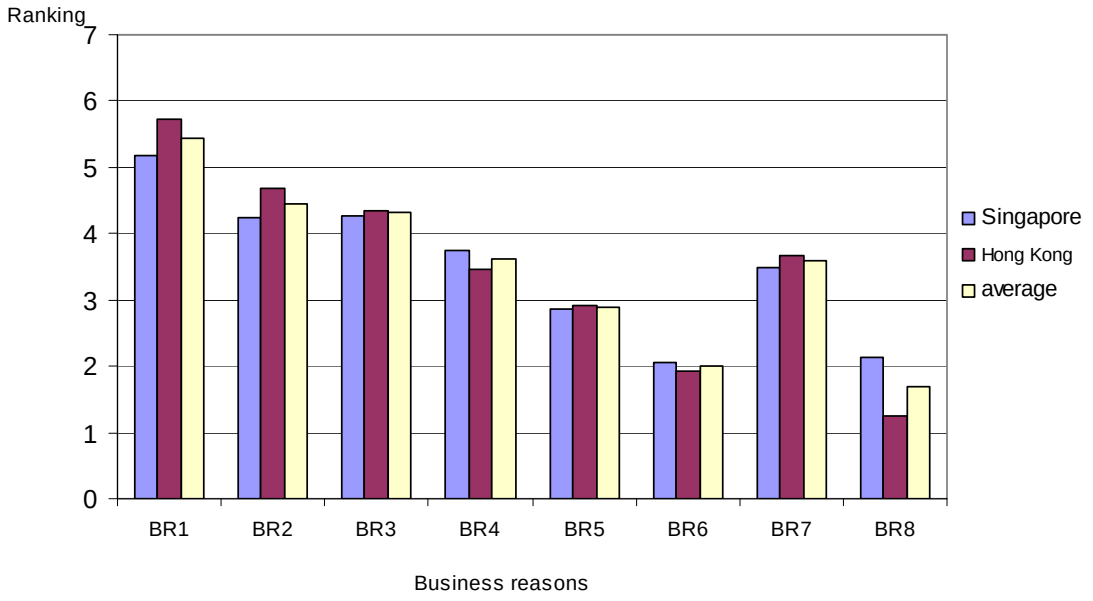

Figure 5.1: Business Reasons (BR) that drive GB

Where: BR1 - Lower operation costs; BR2 - Higher building value; BR3 - Lower lifetime cost; BR4 - Higher return on investment (ROI); BR5 - Help to transform the market; BR6 - Increase staff productivity and retention; BR7 - Enhanced marketability; BR8 - Reduced liability and risk.

Figure 5.1 shows a list of business reasons that make GB more attractive, with a ranked order that is agreed upon by building designers. It illustrates a strong consensus of opinion between building designers in Hong Kong and Singapore about the business reasons. “Lower operation cost”, “higher building value”, and “lower lifetime cost” are the highest ranked business reasons that are commonly acknowledged by both groups. Apart from these, “Enhanced marketability” is also deemed a reason that attracts business interests. “Increased staff productivity and retention” and “reduced liability and risk” are considered to be the least important.

5.5.2.2 Findings on "Obstacles"

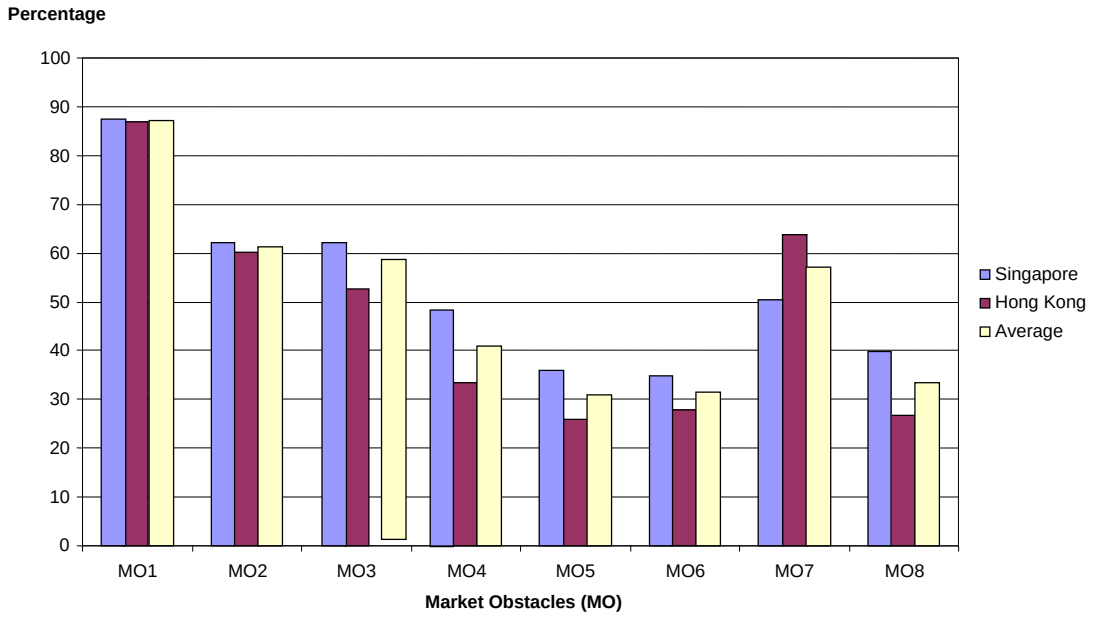

Figure 5.2: Market obstacles (MO) to GB

Where: MO1 - perceived higher upfront costs; MO2 - lack of education; MO3 - lack of awareness MO4 - different accounting methods- such as, capital costs, operating costs; MO5 - no coordination and consistency in rating tools and standards; MO6 - unrecognized eco labeling for products and materials; MO7 - no fiscal incentives from government; MO8 - lack of research and case studies

Figure 5.2 shows that building designers in both cities have quite similar perceptions of the obstacles that hinder GB survival in the market. The architects in both groups agree that "perceived higher upfront costs" is the undeniable obstacle that should arouse attention, followed by "lack of education", "no fiscal incentives", and "lack of awareness". Building designers in the two cities have almost the same percentage of agreement on the issues of "perceived higher upfront costs" and "lack of education", which again indicates the similarity of these two groups.

In both Hong Kong and Singapore, the issues of "no coordination and consistency in rating tools and standards," "lack of research," and "unrecognized eco-labeling" are seen by fewer building designers as the main obstacles for GB.

5.5.2.3 Findings on "Favorable Factors"

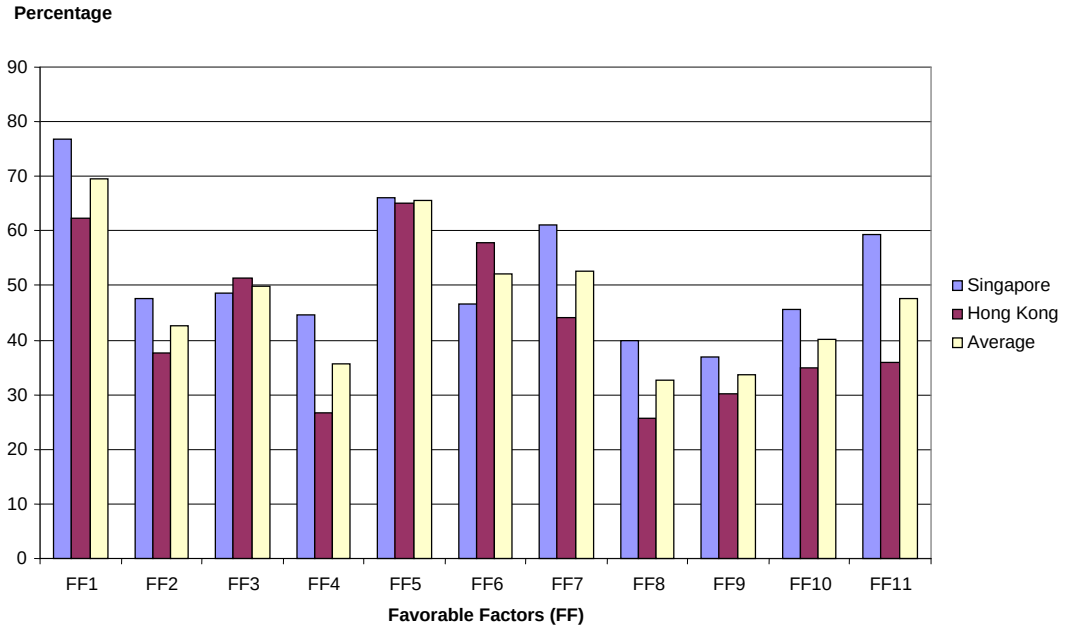

Figure 5.3: Favorable Factors (FF) furthering GB development

Where: FF1 - rising energy costs; FF2 - superior performance of GB; FF3 - client demand; FF4 - industry rating system: e.g. LEED, Green Star, Green Mark, etc.; FF5 - government regulations/ building code; FF6 - lower lifecycle costs of GB; FF7 - worsening environmental conditions; FF8 - competitive advantage of green projects; FF9 - higher tenant satisfaction and productivity in GB; FF10 - increased education on GB; FF11 - greater availability and affordability of GB technology

The overall results in Figure 5.3 show that over 50% of designers in both groups believe that "rising energy costs", "government regulation/building codes", "lower lifecycle costs of GB" and "worsening environmental conditions" are the main favorable factors, while "competitive advantages of GB" and "higher tenant satisfaction and productivity in GB" are deemed the least important factors in furthering the development of the GB market in both Hong Kong and Singapore.

The remarkable difference in the perceptions of "greater availability and affordability of GB technology" between these two groups is also noted. Up to 60% of designers in

Singapore regarded it as a favorable factor, but this was shared by less than 40% of their counterpart in Hong Kong.

From the above data analysis, it can be observed that the respondents from Hong Kong and Singapore share common perceptions on the business issues for the GB market, which further suggests the comparability of the two cities and that they are good representatives of a developed market economy in Asia for the purpose of this study. The professional views are quite consistent on the three main issues being studied. This is further reinforced by the statistical validation carried out in the previous section, *Analysis of respondents and responses*. The survey results assist in delineating the real needs for GB development in a developed market economy in Asia. The findings also support the theoretical basis of the study and justify the objectives. The findings from the interview and questionnaire survey will be triangulated with that of the game modeling and the questionnaire survey results to draw the overall conclusions. It is a crossing referencing process of the findings from the three methodologies- the theoretical game modeling, the empirical studies, and the triangulation analysis, which has been tested/ validated by each other.

CHAPTER SIX: DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS

Overview

To achieve the aim of this study, it has set out objectives/sub-objectives and corresponding research questions to be addressed. It has conducted 3 sets of independent analysis, namely the game theory modeling of decision-making of stakeholders, the Interview survey with Hong Kong developers/professionals, the questionnaire survey of the GB market situation in Singapore/Hong Kong. Each of these analyses has set up hypotheses to be tested and has produced findings and conclusions for that area of study. This chapter first recap and extract the essences of the findings/conclusions from each of the 3 analyses. It tries to triangulate those findings/conclusions and consolidate into common and important issues for discussions and recommendations

6.1 RESPONSE TO OBJECTIVES AND SUB-OBJECTIVES

Table 6.1 summarizes how each of the objectives/sub-objectives and corresponding research questions have been addressed in the appropriate analyses and chapters location of this thesis. The table provides an overall view to ensure all objectives/sub-objectives have been adequately responded. Details can be found under column 4: Checklist of Responses to the (sub) objectives/research questions.

Table 6.1 Summary of Responses to the Objectives and Research Questions

Objectives	Sub-objectives	Research questions under each objective	Checklist of responses to the (sub) objectives/research questions
(1) To establish an analytical framework for understanding the barriers to BEE investment with consideration of transaction costs, by:	(i) identifying the business barriers to BEE for market stakeholders: the developers and end-users;	1) What are the business reasons, market obstacles, and other factors that help to affect the development of green buildings and energy efficiency? 2) What types of barriers exist in the BEE market? 3) What are the barriers for BEE for different market stakeholders during the real estate development process?	Objective (1) and its sub-objectives have been successfully addressed in the Literature Review in Chapter 3, which establishes a valid analytical framework and solid groundwork for the theoretical and empirical studies in subsequent chapters. The market questionnaire survey in Chapter 5 has adequately addressed Question (1), and the interviews in Chapter 5 have provided a detailed answer to Question (3). The combined results of the questionnaire survey and interviews in Chapter 5 provide a detailed answer to Question 4.
	(ii) Investigating the stakeholders' transaction costs as business barriers to BEE in the real estate development process.	4) How are those barriers identified as affecting particular stakeholders connected to transaction costs during the real estate development process?	
(2) To build a theoretical game model of decision-making among the BEE market stakeholders, to explain:	(i) why, at a general level, transaction costs affect stakeholders' decisions in investing in BEE; and	5) What are the outcomes of the game between developers with consideration of transaction costs under different market conditions? 6) What are the outcomes of the game between the developers and end-users with consideration of transaction costs under different market conditions?	Hypotheses related to Objective (2) and its sub-objectives have been successfully addressed in Chapter 4, *Modeling the BEE Market*, which provides a compelling theoretical explanation of why and how transaction costs affect the decision-making of the stakeholders in BEE.
	(ii) what the dominant factors are that affect stakeholders' decisions.		

(3) To study the empirical data from questionnaire surveys of building designers and from focused interviews with real estate developers in Hong Kong:	(i) to identify the transaction costs concerns that are specific to real estate development involving BEE.	7) What are the barriers to BEE for real estate developers during the real estate development process? 8) What extra work arises from barriers at different stages of BEE development in real practice?	Hypotheses related to Objective (3), its sub-objectives, and corresponding Questions 7 and 8, have been successfully addressed through an interview survey with developers in Hong Kong. This can be found in the first section of chapter 5.
	(ii) to find out the real market concerns in practice; and	9) What are the corresponding transaction costs specific to different stages of BEE development in real practice?	Hypotheses related to Objective (3), its sub-objectives, and corresponding Question 9 have been successfully addressed by a questionnaire survey in Hong Kong and Singapore with building designers in the second half of Chapter 5.
(4) To triangulate the study's empirical findings with those of the theoretical model and analytical framework, to:	(i) demonstrate how the theoretical game model approach and analytical framework can be used to explain the general workings of the BEE market and also to accommodate specific operations in different institutions; and	10) How do the theoretical findings fit the empirical case studies? How far can the theoretical game model and analytical framework explain the working of the BEE market in the real world? 11) How do the interviews and questionnaire survey results echo the findings of the theoretical game model and analytical framework?	Sub-objective (i) and corresponding Questions 10 and 11 are adequately addressed in Chapter 6 based on the findings from Chapters 4 and 5, using triangulation analysis methods to provide a holistic view of the BEE market in the real world.
	(ii) explore how institutions might help overcome BEE barriers for different market stakeholders in terms of transaction costs and what roles government might play in promoting BEE.	12) How might institutions, in the Hong Kong case, help to overcome these BEE barriers in terms of transaction costs for different market stakeholders? 13) What roles can government play via the establishment of institutional rules to promote the BEE market?	Sub-objective (ii) and corresponding Questions 12 and 13 are adequately addressed in Chapter 6 based on the findings from Chapters 4 and 5, using triangulation analysis methods to delineate how and what the government is called upon to do given the real concerns of the market.

6.2 PROOFS OF HYPOTHESES

Presented in the table below are extracts from the three analyses to show to what extent each of the hypotheses is supported and with what data. Table 6.2 shows the tests of hypotheses about Objective 2, which is addressed by game theoretic modeling in Chapter 4. Table 6.3(A) and Table 6.3(B) present the tests of hypotheses for Objective 3, which has two sub-objectives. The support for the hypotheses related to objective 3(i), "to identify the transaction costs concerns specific to the real estate development process of BEE projects" is presented in Table 6.3(A) with data collected in the interview survey with developers/professionals in Hong Kong. The tests of hypotheses related to objective 3(ii) "to find out the real market concerns in practice" are shown in Table 6.3(A) based on questionnaire data collected in Singapore and Hong Kong.

The author has set five levels of agreement: "strongly supported", "supported", "partially supported", "marginally supported" and "not supported", which are conceptualized scale, indicating the five different degrees of agreement between the hypotheses set originally, and the findings that echoes the hypotheses. Because the interviews are qualitative research, it is not possible to set a liner scale among the five degrees of "….supported" in order to evaluate the levels that the hypotheses been tested. The "strongly supported" and "supported" are different levels of positive proof to the hypotheses, while "not supported" is a definite negative proof to the hypotheses. "Partially supported" means there are diverse opinions, both positive and negative, to the proof of the hypotheses, however, the positive are dominating the negative views, which overall the hypotheses are proved to be right. "Marginally supported" is like "partially supported" with more diverse views, which the positive and negative are more or less even off, and the hypotheses are difficult to judge if it could be proved or not. The overall judgments for each of the hypothesis are based on the answers collected from the interviewees- the dominating views, and to be decided by the author's overall knowledge on the topic, which is both the merit and the difficult part as the qualitative research.

6.2.1 Proofs of Hypotheses to Objective 2:

There are two sub-objectives:

2(i): To determine why transaction costs affect decision-making about BEE among the stakeholders; and

2(ii): To delineate the dominant factors that affect the decision-making of the stakeholders?

The following tables summarize how well the research supports the hypotheses and answers the corresponding questions.

Table 6.2 Proofs of Hypotheses to Objective 2:

Sub-objective **2(i):** why, at a general level, transaction costs affect stakeholders' decisions in investing in BEE; and **2(ii):** what are the dominant factors that affect stakeholders' decisions?			
Game model the between the developers without transaction costs			
Hypothesis H1 (GM): 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 two developers combined in a competitive market.	**Corresponding Questions**	**Tests carried out**	**Overall Result**
	Q.5 What are the outcomes of the game between developers with consideration of transaction costs under different market conditions?	As proven for **Proposition 2** in section 3.3.1 of Chapter 4.	**Supported**
Transaction costs from the perspective of uncertainties			
Hypothesis H2 (GM): In the Bayesian Cournot game model between developers with incomplete information, developer, who develops genuine BEE products, will develop smaller quantity of BEE, comparing with that in a complete information market, in light of transaction costs incurred by uncertainties.	**Corresponding Questions**	**Tests carried out**	**Overall Result**
	Q.5 What are the outcomes of the game between developers with consideration of transaction costs under different market conditions?	As proven for **Proposition 5** in section 3.3.3 of Chapter 4.	**Supported**
Hypothesis H3 (GM): In the Bayesian Cournot game model between the developers with incomplete information, the total supply of genuine BEE products in the market would decrease if the proportion of credible developers in the market decreases, implying that unfair competition worsens the BEE market development.	Q.5 What are the outcomes of the game between developers with the consideration of transaction costs under different market conditions?	As proven for **Proposition 6** in section 3.3.3 of Chapter 4.	**Supported**
Game model between the developers and the end-users with transaction costs			
Hypothesis H4(GM)	**Corresponding Questions**	**Tests carried out**	**Overall Result**

At the unique equilibrium price of BEE products in the game model between the developer and the end-users with transaction costs, the payoffs for the developer and the end-user are less than those in the scenario without transaction costs and are proportional to their bargaining powers.	Q.6 What are the outcomes from the game between the developers and the end-users with the consideration of transaction costs under different market conditions?	As proven for **Proposition 9** in section 4.3.2 of Chapter 4.	**Supported**
Transaction costs from the perspective of uncertainties (equilibrium outcomes for the developer)			
Hypothesis H5(GM) If the developer chooses to develop BEE products, the expected utility will increase with the improvement of utility for the end-user who purchases BEE products.	**Corresponding Questions**	**Tests carried out**	**Overall Result**
	Q.6 What are the outcomes from the game between the developers and the end-users with the consideration of transaction costs under different market conditions?	As proven for **Proposition 12** in section 4.3.3 of Chapter 4.	**Supported**
Hypothesis H6(GM) If the developer chooses to develop BEE products, the expected utility will decrease with the increase in the development costs of BEE or transaction costs for the developer.	Q.6 What are the outcomes of the game between the developers and the end-users with the consideration of transaction costs under different market conditions?	As proven for **Proposition 13** in section 4.3.3 of Chapter 4.	**Supported**
Transaction costs from the perspective of discount rate			
Hypothesis H7(GM) The expected payoff for the end-user in the game model between the developer and the end-user with discount rates is smaller than that in the scenario without transaction costs and discount rates.	**Corresponding Questions**	**Tests carried out**	**Overall Result**
	Q.6 What are the outcomes of the game between the developers and the end-users with the consideration of transaction costs under different market conditions?	As proven for **Proposition 19** in section 4.3.3(2) of Chapter 4.	**Supported**
Hypothesis H8(GM) The expected payoff for the developer in the game model between the developer and the end-user with discount rates is smaller than that in the scenario without transaction costs and discount rates.	Q.6 What are the outcomes of the game between the developers and the end-users with the consideration of transaction costs under different market conditions?	As proven for **Proposition 20** at section 4.3.3(2) of Chapter 4.	**Supported**

6.2.2 Proofs of Hypotheses to Objective 3

There are two sub-objectives:

3(i) To identify the transaction-costs concerns that are specific to real estate development involving of BEE; and

3(ii) to find out the real market concerns in practice.

Hypotheses and corresponding questions have been established. The following tables summarize how and where they are proven.

Table 6.3 (A) Transaction-cost concerns specific to the REDP of BEE projects (based on interview data)

Sub-objective 3(i): To identify the transaction-costs concerns that are specific to real estate development involving of BEE.			
Specific Investment			
Hypothesis <u>H1</u> (SI): Dividing the transactions of the real estate development (RED) process into smaller established stages helps government to better understand the process and make policies with a more focused emphasis on the different stages of transaction to promote BEE more efficiently.	**Corresponding Questions**	**Dominant Answers**	**Overall Result**
	Q.1 Which stages are of most concern to real estate developers considering BEE?	**Question 1 is intended to illuminate the role of concerns about TC at different stages of the RED process. The answers to Question 1 and related results will be presented in greater detail below. (see section 6.3)**	**There is a list of hypotheses for Question 1.**
	Q.2 What are the reasons developers are willing to buy new appliances/ technology without government incentives? How much of a price difference (in terms of the percentage of the total development cost) would they accept?	Most of the interviewees believe the main reasons are "goodwill for society, branding, and company image," and "market demand." Most of the interviewees would accept a price difference of less than 5% of the investment.	**Hypothesis <u>H1</u> (SI) is supported** **Remarks:** Valuable information has been obtained by dividing the transactions in the entire real estate development process into smaller demarcated stages to
	Q.3 Uneven emphasis on incentives: What	Most of the interviewees agree that government	

	facilities/building elements are more expensive/difficult to be retrofitted later if not installed in the first place? Should they be emphasized in incentives to promote BEE investment? Why?	incentives should emphasize that those elements that are more expensive and difficult when retrofitted should be installed at the outset of the project. Most of them vote for the "envelope, curtain walling" as an example.	conduct the interviews. The answers to Question 1 are in a later section (see….) and provide even more significant support for Hypothesis H1.
	Q.4 What are the differences between the concerns of those investing in luxury buildings and in lower-price buildings? Why?	Most of the interviewees agree that luxury buildings are much more likely to include green features.	
	Q.5 There are misplaced benefits between the people who pay and who gain from BEE. To address this problem, would rental/selling price differences help? What other means might help address the problem of misplaced benefits?	Most of the interviewees agree that the problem of misplaced benefits is difficult to address but agree that a different rental/selling price will help motivate BEE investments without misplaced benefits.	

Sub-objective 3(i): To identify the transaction-costs concerns that are specific to real estate development involving of BEE.			
Frequency			
Hypothesis <u>H2</u> (F): There is a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects.	**Corresponding Questions**	**Dominant Answers**	**Overall Result**
	Q.6 Will the size of the project affect the developers' concerns about BEE investments?	Most of the interviewees agree that the "larger project induces more uncertainty; hence, only well-tested green features will be incorporated in larger ones."	**Hypothesis <u>H2</u> (F) is supported.**

	Q.7 Will the size of the real estate development company affect the developers' concerns about BEE investment?	A large majority of the interviewees agree that "the size of the real estate development company affects the developers' concern about BEE investment."	
Hypothesis <u>H3</u> (F): There is a positive relationship between the frequency of BEE investment and the concerns about transaction costs in developing BEE projects.	**Corresponding Questions**	**Dominant Answers**	**Overall result**
	Q.8 How does the frequency of BEE investment a regular, occasional, or one-time developer affect the concerns in BEE investment?	A large majority of the interviewees agree that "the more frequent the BEE investment, the fewer the concerns of the developers."	**Hypothesis <u>H3</u> (F) is STRONGLY supported.**
	Q.9 Would the developers' concerns change if they invested in BEE projects more frequently? Why?	Most of the interviewees believe that developers' concerns will change if invest in BEE projects more frequently.	

Sub-objective 3(i): To identify the transaction-costs concerns that are specific to real estate development involving of BEE.			
Economic uncertainties			
Hypothesis <u>H4</u> (EU): The economic context (upturn or downturn economic transition) affects the concerns of the real estate developers about BEE investment.	**Corresponding Questions**	**Dominant Answers**	**Overall Result**
	Q.10 At times of economic transition, what new challenges or opportunities arise for investments in BEE? How do shifts in the economy change the developers' major concerns (neutral, positive, or negative) and in which aspects?	There are quite varied viewpoints and therefore it is difficult to generalize a single conclusion from them. More than half of the interviewees agree that "periods of economic downturn offer a better chance to further green/BEE development, because people expect change at such times."	**Hypothesis <u>H4</u> (EU) is NOT supported.**
	Q.11 When the direction of the economy shifts, how might developers integrate green features into original investments to increase market	Most respond that "in economic downturns, developers would mainly add the green image to improve their brand-names, but the end result is not very significant.	

	competitiveness?		
Hypothesis <u>H5</u> (EU): Changes in economic conditions (upturns and downturns) call for the attention of government to adjust BEE policies as necessary to seize BEE development opportunities.	**Corresponding Questions**	**Dominant Answers to the Question**	**Overall Result**
	Q.12 What role should government play in BEE promotion (more intervention or less intervention in a recessionary economy)?	Most people agree that "Basically, during economic upturns, government incentives or promotional efforts are less effective than during downturns, because property sells well and the buyers are less concerned about green features."	**Hypothesis <u>H5</u> (EU) is PARTIALLY supported.**
	Q.13 What BEE promotions or incentive could government introduce in times of economic change that would be less upsetting to the market players' normal activities?	During the economic downturn, government incentives are more important, because the developers are more reluctant to invest in BEE and people who buy also need to be more assured of the benefits of green incentives."	

Sub-objective 3(i): To identify the transaction-costs concerns that are specific to real estate development involving of BEE.			
<u>Market uncertainties</u>			
Hypothesis <u>H6</u> (MU): The end-users' variable expectations about BEE increase market uncertainty to the developers, e.g., they may misinterpret a focus group as the end-users for their final products.	**Corresponding Questions**	**Dominant Answers to the Question**	**Overall Result**
	Q.14 Occupants' behavioral differences may lead developers to produce different BEE/GB at different performance levels. What is your view?	Most believe behavioral variety among occupants leads developers to produce BEE/GB at different performance levels, calling for standard measurement for BEE performance.	**Hypothesis <u>6</u> (MU) is PARTIALLY supported.**
	Q.15 Will concerns about social classes (education levels, experiences, financial ability to enjoy the benefits of BEE) affect the developers' BEE investment?	Two equally weighted views have been found.	

Sub-objective 3(i): To identify the transaction-costs concerns that are specific to real estate development involving of BEE.			
Policy uncertainties			
Hypothesis H7 (PU): The earlier the stage of BEE policy implementation, the greater the concerns about the terms of transaction costs incurred by real estate developers.	**Corresponding Questions**	**Dominant Answers**	**Overall Result**
	Q.16 Would new incentive and currently mature incentive affect developers' concerns about BEE differently? Encountering BEE incentives, would the developers have more concerns during the early or later stage of the implementation?	Most think "more concerns arise during the early stage because of greater uncertainty."	**Hypothesis H7 (PU) is supported.**

Table 6.3(B): Real market concerns in practice (based on questionnaire data)

Sub-objective 3(ii): to find out real market concerns in practice;			
Economic uncertainties			
Hypothesis B1: Cost concerns are the major business reasons that make the BG market attractive for investment.	**Corresponding Questions**	**Dominant Answers**	**Overall Result**
	What are the major business reasons that drive the GB market?	"Lower operating costs," "higher building value," and "lower lifetime cost" are the highest ranked business reasons, all cost related.	**Hypothesis B1 is STRONGLY supported.**
Hypothesis B2: Cost concerns are the major obstacles that hinder investors from entering the GB market.	What are the major obstacles to GB?	"Perceived higher upfront costs" is the undeniable obstacle, followed by "lack of education," "no fiscal incentives," and "lack of awareness." Two of the top three are cost-related.	**Hypothesis B2 is supported.**
Hypothesis B3: Cost concerns are the major factors that help to advance GB development.	What are the major favorable factors that further GB development?	"Rising energy costs," "government regulation/building codes," "lower lifecycle costs of GB," and "worsening environmental conditions" are the main factors that favor investment. Two of the top four are cost-related.	**Hypothesis B3 is marginally supported.**

6.3 TRANSACTION COSTS CAUSED BY BEE AT DIFFERENT STAGES OF THE BEE DEVELOPMENT PROCESS

Sub-objective 3(i), which aimed to identify the concerns specific to BEE projects, could be addressed more explicitly by dividing the transactions of the entire real estate development process into smaller established stages. This would help the government to better understand the market and to develop policies with a more focused emphasis on the different stages of transactions, thus promoting BEE more efficiently with appropriate policies. Table 3.4 shows the concluding findings from one of the interview questions (Question 1). It helps to address the following questions:

1) **What are the extra tasks arising from the barriers at different stages of BEE development in actual practice?**

2) **What are the corresponding transaction-cost concerns specific to different stages of the BEE development in actual practice?**

The key conclusions are that additional tasks are more likely to arise during the early period (briefing stages) of a BEE project than at other stages. The area of greatest concern is the possibility of extra legal liability in relation to the BEE product due to uncertainties about the market, consumers, and available technical information. The other risk items mainly relate to extra study and knowledge about the market. At the sketch-plan stage, the task with the highest risk is the cost of study involved in incorporating new design features and exploring special technical solutions for BEE projects. At the working-drawing stage, the high-risk task is looking for suitable contractors to construct the BEE project. By the site-operation stage, there are fewer concerns. Opinions are diverse and “Extra requirements for testing and commissioning,” which again deals with new knowledge, is the top risk item. At the feedback and maintenance stage, the risks are general, and views about them very diverse. The highest concerns for risk (TC) mostly relate to marketing and leasing. Generally, the latter half of a BEE project does not involve too many extra tasks or concerns about risk.

Table 6.4 Major transaction costs (risks) caused by BEE at different stages of the development process

	Extra tasks arising from BEE	Remarks
Briefing stage	1. Consideration of extra legal liability arising from the BEE product.	Very diverse opinions, but tends to be seen as high and very high risk.
	2. Carrying out extra studies of market requirements and expectations for BEE (considering local community needs/supply/competitiveness).	Very consistently high risk.
	3. More careful review of the available information on BEE products.	Consistently high risk.
	4. Considering extra BEE-related market and policy requirements.	Consistently high risk.
	5. Extra effort to identify potential users.	Consistently high risk.
Sketch Plans	6. Special cost studies for using new design features.	Very consistently high risk.
	7. Exploring special technical solutions.	Consistently high risk.
	8. Searching for a list of contractors with special expertise.	Consistently high risk.
Site operation stage	9. Extra requirements for testing and commissioning service installations to obtain Green Labeling, etc.	Diverse opinions tend toward high risk.
	10. Special promotional strategies and materials for marketing and leasing.	Diverse opinions tend toward high risk
	11. Additional consideration of tenants for BEE products.	Very diverse opinions between high and standard risk.
Feedback and Maintenance	12. Special strategies and materials for overall marketing or leasing of the completed green/BEE building.	Very diverse opinions, but mostly between high and very high risk.
	13. Ease of selling or renting property (e.g., will it involve more guarantee certificates?).	Very diverse opinions tending toward high risk.
	14. Special property skill requirement for property management plan.	Very diverse opinions, tending to be between high risk and standard risk.

6.4 TRIANGULATING THE HYPOTHESES/FINDINGS FROM THE THREE RESEARCH METHODS

This study has set out objectives, sub-objectives, and corresponding research questions to be addressed. It has conducted three sets of independent analyses, a game-theoretic modeling of the decision-making of stakeholders, an interview survey with Hong Kong developers/professionals, and a questionnaire survey of the GB market situations in

Singapore and Hong Kong. Each of these analyses has developed hypotheses to be tested and has produced findings and conclusions for that area of study.

This section reviews the hypotheses developed from the three areas of analysis and the outcomes tested. Then, it triangulates the research from the three analyses to find common issues as presented in Table 6.5. The following summarizes the outcome of each hypothesis.

6.4.1 Hypotheses from Game Modelling

Hypothesis H1 (GM): The 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 the profits of the two developers combined in a competitive market.	**Supported**
Hypothesis H2 (GM): In the Bayesian Cournot game model between the developers with incomplete information, Developer 1, who develops genuine BEE products, will develop smaller quantities of BEE comparing with that would be developed in a complete-information market in light of transaction costs may incurred by uncertainties.	**Supported**
Hypothesis H3 (GM): In the Bayesian Cournot game model between the developers with incomplete information, the total supply of genuine BEE products in the market would decrease if the proportion of credible developers (who develop genuine BEE products) in the market decreases, implying that unfair competition situation worsens BEE market development.	**Supported**
Hypothesis H4(GM) At the unique equilibrium price of BEE products in the game model between the developer and the end-user with transaction costs, the payoffs for the developer and the end-user are less than those in the scenario without transaction costs and proportional to their bargaining powers.	**Supported**
Hypothesis H5(GM) If the developer chooses to develop BEE products, the expected utility will increase with the improvement of utility for the end-user from purchasing BEE products.	**Supported**
Hypothesis H6(GM) If the developer chooses to develop BEE products, the expected utility will decrease with the increase in development costs of BEE or transaction costs for the developer	**Supported**
Hypothesis H7(GM) The expected payoff for the end-user in the game model between the developer and the end-user with discount rates is smaller than that in the scenario without transaction costs and discount rates.	**Supported**
Hypothesis H8(GM) The expected payoff for the developer in the game model between the developer and the end-user with discount rates is smaller than that in the scenario without transaction costs and discount rates.	**Supported**

6.4.2 Hypotheses from Interview Survey

Hypothesis H1 (SI): Dividing the transactions of the real estate development (RED) process into smaller established stages helps government to better understand the process and make policies with a more focused emphasis on the different stages of transaction to promote BEE more efficiently	**Supported**
Hypothesis H2 (F): There is a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects.	**Supported**
Hypothesis H3 (F): There is a positive relationship between the frequency of BEE investment and the transaction costs (concerns) incurred in developing BEE projects.	**STRONGLY supported**
Hypothesis H4 (EU): The economic context (upturn or downturn economic transition) affects the concerns of the real estate developers about BEE investment.	**NOT Supported**
Hypothesis H5 (EU): Changes in economic conditions (upturns and downturns) call for the attention of government to adjust BEE policies as necessary to seize BEE development opportunities.	**PARTIALLY Supported**
Hypothesis H6 (MU): The end-users' variable expectations about BEE increase market uncertainty to the developers (e.g. ., they may misinterpret a focused group as the end-users of their final products.	**PARTIALLY Supported**
Hypothesis H7 (PU): The earlier the stage of BEE policy implementation, the higher the concerns in terms of transaction costs incurred by real estate developers.	**Supported**

6.4.3 Hypotheses from Questionnaire Survey of the market

Hypothesis B1: Cost concerns are the major business reasons that make the BG market attractive for investment.	**STRONGLY supported**
Hypothesis B2: Cost concerns are the major obstacles that hinder investors from entering the GB market.	**Supported**
Hypothesis B3: Cost concerns are the major factors that help to advance GB development.	**Marginally supported**

6.4.4 Significant hypotheses tested with data from industry

Table 6.5 shows that most of the hypotheses from the game modeling find support from other research methods. This is not surprising because they serve to reconfirm

established TCE theory. It is more interesting to look for those results in the two surveys that show the degree to which the significant hypotheses capture how closely the real world compares with established TC theory. Therefore, based on Table 6.5, the following are the list of significant hypotheses to be tested with data collected from industry.

Hypothesis H2 (F): There is a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects.	**Supported**
Hypothesis H3 (F): There is a positive relationship between the frequency of BEE investment and the transaction costs (concerns) incurred in developing BEE projects.	**STRONGLY supported**
Hypothesis H5 (EU): Changes in economic conditions (upturns and downturns) call for the attention of government to adjust BEE policies as necessary to seize BEE development opportunities.	**PARTIALLY Supported**
Hypothesis H6 (MU): The end-users' variable expectations about BEE increase market uncertainty to the developers (e.g. ., they may misinterpret a focused group as the end-users of their final products.	**PARTIALLY Supported**

Table 6.5 Compare the hypotheses from the three research methods

Hypotheses from Game Modeling	**Hypotheses from Interview/Questionnaire Surveys providing Support**	**Remarks**
Hypothesis H1 (GM): Quantity of BEE developed in the monopoly market is smaller than in the perfect market, but the monopoly profit is bigger than profits combined in competitive market. **Supported**	**Hypothesis H2 (F):** There is a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects. **Supported**	Government should intervene to avoid monopoly.
Hypothesis H2 (GM): In the Bayesian Cournot game model between the developers with incomplete information, Developer 1, who develops genuine BEE products, will develop a smaller quantity of BEE comparing with that would be developed in a complete information market in light of transaction costs generated by	**Hypothesis H3 (F):** There is a positive relationship between the frequency of the BEE investment and the transaction costs incurred in developing BEE projects. **STRONGLY supported** **Hypothesis B2:** Cost concerns are the major obstacles that hinder investors from entering the GB market. **Supported**	Government should intervene to regulate or provide information to remove uncertainty.

uncertainties. **Supported**		
Hypothesis H3 (GM): In Bayesian Cournot game model between developers with incomplete information, the total supply of genuine BEE in market decreases if credible developers decrease, implying that unfair competition worsens BEE development. **Supported**	**Hypothesis B2:** Cost concerns are the major obstacles that hinder investors from entering the GB market. **Supported**	Require incentives to cut costs and avoid unfair competition.
Hypothesis H5 (GM) If the developer chooses to develop BEE products, the expected utility will increase with the improvement of utility for the end-user who purchases the BEE product. **Supported**	**Hypothesis H6 (MU):** The end-users' variable expectations about BEE increase market uncertainty to the developers (e.g., they may misinterpret a focused group as the end-users of their final products. **(PARTIALLY Supported)** **Hypothesis B2:** Cost concerns are the major obstacles that hinder investors from entering the GB market. **Supported** ("Lack of education and awareness" are among the top.)	The government could identify and segment the end-users into different categories, such as newly graduated university students, who are well aware of green technology but cannot afford, or distinguish the end-users by the size and frequency with certain types of incentives.
Hypothesis H6 (GM) If developer chooses BEE products, the expected utility will decrease with the increased costs (TCs) of BEE. **Supported**	**Hypothesis B2:** Cost concerns are the major obstacles that hinder investors from entering the GB market. **Supported**	Require incentives and cut costs, including transaction costs.
Hypothesis H7 (PU): The earlier the stage of BEE policy implementation, the higher the concerns in terms of transaction costs incurred by real estate developers. **Supported**	**Hypothesis B1:** Cost concerns are the major business reasons that make the GB market attractive for investment. **STRONLY supported** (During the early stage, more tasks involved.)	Government policies should address the problems of the early stages. New incentives should avoid uncertainties earlier.

6.5 THEMES FOR DISCUSSION AND RECOMMENDATION

Through comparative analysis and triangulation, we have found hypotheses supported by different research methods that have found support from each other. Many of the hypotheses developed with close reference to TCE theory have been proven by the

game-theoretic model. This study also tests those TC theories in the real world through a questionnaire survey and through interviews based on the case study of Hong Kong. Appendix 6 consolidates the conclusions and comments from the three research methods and considers them under several themes: Competition in the BEE Market, Uncertainty, Incomplete Information, and Costs as the Major Concern, Government Intervention, Government Intervention at Different Stages, and Policy Packages (Incentives).

6.5.1 Competition in the BEE Market

- Supply of BEE in a competitive market is greater than that in a monopoly market, thus, governments policies should break up monopolies and encourage competition, for example in the land market, to promote BEE development from the supply side.
- Increased competition in the BEE market benefits the end-users in two ways, by providing more BEE products and by increasing the total consumer surplus in the market.

- "Rising energy costs," "government regulation/building codes," "lower lifecycle costs of GB," and "worsening environmental conditions" are the main factors that encourage GB development. Without government's moderating role in controlling these factors, they could lead to unfair competition.

6.5.2 Uncertainty

- In a BEE market with uncertainties, the developers will develop smaller quantities of BEE products compared with a market with complete information. In light of transaction costs generated by uncertainties, increasingly smaller quantities of BEE will be developed as uncertainty rises. Government should intervene to regulate or provide information to remove as much uncertainty as possible.

- Most people think that more concerns arise during the early stages of development because of more uncertainty. Most people agree that the government can do better on the basis of international experience and practices. The government could first

take part in the new movement by integrating their new pilot or demonstration projects and sharing the experience with the market. After a certain period of time, a few years, they could delineate these concerns and then mandate a solution to the market.

- In general, the majority of respondents agree that for a new incentive, the greatest concern for the market is if it is stable and long lasting. Therefore, the more established the incentive, the less the concern, and the earlier the stage, the greater the challenge.

- Industry rating systems, such as Green Star and LEED, are gaining wide recognition in GB development. It is surprising to find in the market survey that "industry rating systems" are not, in the assessments of building designers, the most important favorable factor that motivates the GB market. This is not consistent with findings of a previous study for Singapore in which architects complained about a lack of consistent, accurate, and reliable environmental information for GB design. The result here may be due to the lack of detailed knowledge about and a consensus approach for delivering GB. For example, the lack of detailed knowledge about GB rating systems or green concepts may lead to developers' reluctance to rely on the rating systems or invest in GB. An alternative explanation for such a ranking could be that the building designers may believe there is already enough research and effort devoted to developing industry rating systems.

6.5.3 Incomplete Information

- The 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 the profits of the two developers combined in a competitive market. Government should intervene to avoid monopoly.
- From the perspective of the whole society, the total supply of BEE products would decrease if incomplete information or unfair competition worsened the BEE market.

This implies that the benefits brought by BEE to the welfare of society would decrease accordingly. Therefore, the quantity of BEE products in the new equilibrium would decrease further, showing that incomplete information with unfair competition undermines the reputation of BEE and jeopardizes the healthy development of BEE in the long-term.

- Regarding how social classes might affect the developers' concerns about BEE investments, two equally weighted views have been found. One holds that richer people in higher social classes appreciate the benefits of BEE more than do lower income people. In this case, developers will be attracted to invest in BEE for high-price buildings. The more highly educated will also appreciate BEE more, which could contribute towards a better environment. This suggests that those people who would be easily motivated by BEE business strategy or by government incentives are likely to be both richer and "better educated."

- Most people believe that the diversity of occupants' behaviors could lead developers to produce different BEE/GB at different levels of performance. There is a need to have a standard measurement for buildings so that consumers know what good performance actually is.

- GB, as a new venture delivering new products, requires higher upfront costs, which is a very obvious obstacle to its development. However, this perception of higher upfront costs may be exaggerated due to a lack of real knowledge about the cost of GB. In the market survey, "lack of education" and "lack of awareness" are other obstacles whose importance is supported by other studies (Chew, 1994; Ganeson, 1996; Ofori and Ho, 2004). The factor of "no fiscal incentives" is also an important obstacle that hinders the development of GB. Respondents would like to see government intervention to stimulate the demand for GB. This study also argues that, apart from mandatory government regulations, incentives are most essential to promoting the GB market.

6.5.4 Costs as the major concern

- With incomplete information, a developer who develops genuine BEE products will develop smaller quantities of BEE compared with what would be developed in a complete information market, given transaction costs incurred due to uncertainties.
- There is a positive relationship between the frequency of BEE investment and transaction costs incurred in developing BEE projects. There is also a positive relationship between the size of the company and the transaction costs incurred in developing BEE projects. This is due to economies of scale and the ability of the developer to take risks. However, these two factors also call for government to ensure that they do not result in unfair competition between large and small developers.

- "Perceived higher upfront costs" is the undeniable barrier that should arouse attention. It calls for incentive schemes from government to cut costs and prevent unfair competition.

6.5.5 Government intervention

- The equilibrium price of BEE products is dependent on their cost, benefits, and the relative bargaining power between the developer and the end-user.
- The equilibrium amounts of BEE supply and demand are lower than the socially optimal level, with externalities considered. Government interventions such as incentives and raising awareness are needed to promote the development of the BEE market.
- Economic conditions (upturns or downturns) call for attention by the government to adjust BEE policies in order to seize BEE-development opportunities. Most people agree that during economic upturns, government incentives or promotions are less effective than they are during downturns, because property sells well and buyers are less concerned with green features.

- As set out in the literature review, economic forces and government interventions affect interest in the GB market. Rising energy costs present such an economic condition causing people to take part in GB in their own interest. “Government regulations or building codes” create a mandatory push for people to take part in GB. “Lower lifecycle cost” is a great economic attraction for all stakeholders. These three ranked as the most important factors likely to stimulate GB. Government is expected to do more in this role. However, the benefit to the building-users or the employees, such as “higher tenant satisfaction and productivity in GB,” is considered the least important favorable factor of concern by building designers. This echoes the discussion that the issues directly related to costs and benefits are the major attractions to the business world. This is not an encouraging finding for the overall benefit of society.

- The market survey results also indicate that market challenges for GB are mainly due to the lack of economic and advocacy incentives from the government.

6.5.6 Government invention at what stage

- The earlier the stage of BEE policy implementation, the higher the real estate developers’ concerns about transaction costs.

- The conclusions drawn from the interviews with developers are that during the early period (e.g., the briefing stage) of a BEE project, there are more extra tasks involved than at other stages, and they present higher risks and greater TC concerns.

- Government policies/incentives should address the problem in the early stages of BEE projects. Any new incentives should avoid unnecessary uncertainties for the stakeholder at the early stage of implementation of a new scheme.

- During the economic downturn, government incentives are more important, because the developers are more reluctant to invest in green projects, and people who buy also need to be assured of the benefits of green incentives.

6.5.7 Policy packages (Incentives):

- It is crucial for the government to have long-term strategies and clear policy signals for BEE promotion, to create a positive investment environment and raise the stakeholders' confidence and the market's expectations for business investment in BEE. For example, the government should formulate and implement a package of polices by taking into consideration the impact of transactions on the decisions of market stakeholders.

- Possible policies include energy and carbon tax reforms, ensuring the future business attractiveness of BEE products by setting up reasonable energy prices, raising the awareness of BEE through advocacy and by educating the public to the urgency and importance of energy efficiency, and setting up incentive schemes to reduce the costs to developers and end-users.

- Policies should address the risks (transaction costs) at the following identified stages of the BEE real estate development process:

    - During the early period (briefing stages) of a BEE project development, there are more extra tasks and risks involved than at other stages. The area of greatest concern is the possibility of extra legal liability for BEE products. The other risk items mainly relate to the need for extra study and knowledge about the market.

    - At the sketch-plan stage, the biggest extra task is the cost study for using new design features and exploring special technical solutions.

    - At the working-drawing stage, the greatest extra work comes in looking for a suitable contractor.

    - At the site-operation stage, generally, there is less risk concern at this stage. "Extra requirements for testing and commissioning" is the biggest extra task for this stage.

- At the feedback and maintenance stage, the risks are generally standard. The items of highest concern mostly relate to marketing and leasing. Generally, this stage does not attract too many extra tasks or concerns about risk with transaction costs.

- To improve decision-making in the GB market, the following government actions are called for: :
  - Government's direct intervention is required to moderate energy prices in to make energy-efficient construction a worthwhile effort and a profitable business.
  - Government should impose some basic mandatory requirements to regulate the quality standards of GB. This will deter opportunistic behaviour by the stakeholders in an asymmetrical information market and create a level playing field for all competitors in the GB market.
  - Government should help industry to develop technology and know-how, deliver them at a lower initial cost, and operate them at a low life-cycle cost.
  - Government could help industry by providing economic incentive schemes.
  - GB's underlying value, long-term costs and benefits, and inherent contributions to society should be clearly and widely promulgated to consumers. Their awareness of the need for GB will create a demand market.

6.6 RECOMMENDATIONS FOR POLICY IMPLEMENTATION

Discussions in Section 6.5 mentioned the role of government, which could also be recommendations for policy to help promote BEE. The following summarizes the key items to focus on in making policy recommendations.

6.6.1 From government's perspective

As an authority to set up institutions and design policies, government is more able to improve its own efficiency and internal decision-making than to improve its external

counterpart, the market. Government should adopt a clear national policy to improve energy efficiency through a coherent package of policy measures. Based on the findings in this study, the following are recommended policy innovations:

- Regulate energy prices to meet the actual needs of the building industry. This may require discriminant energy pricing across different industries.

- Mandatory standards should be established for energy-efficient buildings and implemented through legislation. This would clarify the legal liabilities of the parties involved and provide a level playing field for all players.

- Government should provide economic incentive schemes and financial support for energy efficient technologies and for the industry to carry out technological innovations and undertake research-and-development projects to support the continuing improvement of BEE.

- The government could identify and segment the end-users into different categories, such as newly graduated university students, who are well aware of green technology but do not have the financial ability to buy it without incentives. Government could also distinguish end-users by the size or frequency of their investments in green buildings/BEE, given incentives.

- Central governments should leave some flexible levies available for local governments to initiate and implement innovative incentive measures that suit local BEE development because different regions vary in resources and economic development.

- Government should keep policy design and implementation credible with a long-term plan, so that the market has the confidence inherent in a stable policy environment and investment culture, and therefore fewer uncertainties.

6.6.2 From the market's perspective

Policy mechanisms alone will not work and market forces by themselves will not achieve the potential for energy efficiency. Because the spread of energy efficiency improvements cannot be left to the market, there has to be an emphasis on policy-assisted, market-oriented mechanisms for promoting energy efficiency. Based on the findings of this study, any policies that would lead the market in the following directions would be useful:

- Create demand for and appreciation of BEE products; make available BEE-education programs for building professionals and the public.
- Widely promote and supervise labelling programs, publication of BEE product information, and assessment schemes for energy-efficient buildings.
- Set common standards that will lead professionals to strive for excellence in order to capture market share and allow consumers to recognize genuine products.
- Provide updated and transparent information on BEE technologies that are accessible to the public.
- Create a financial advantage for BEE compared with its conventional counterpart, available to both end-users and developers. Saddle conventional technologies and non-BEE with penalties that offset opportunities for free riders.
- Create an economically and politically stable investment environment for BEE business to lower the uncertainties of the market. Provide governmental assistance to protect against the risks arising from construction delays and contract litigation in the implementation of BEE.

Only when both the end-users and the developers appreciate the benefits of energy efficiency building will they create a business channel for BEE products and the BEE market. Policies have to be devised to protect the poor, the environment, and the

future. Each of the barriers discussed above provides an opportunity for policies to address, but it will involve simple matches of one policy to one barrier. It will require a careful selection and combination of a set of policy instruments to overcome these existing barriers. How, then, do we choose among so many policy instruments? Economic theory, along with careful analysis of BEE barriers, provides guidance for matching policies to barriers. Several concerns warrant careful attention in this matching process. First, it is important to understand how effective the intervention will be. Second, the benefits from the intervention must be weighed against the costs of implementing the policy, including both the governmental administrative costs and compliance costs, taking into account the risk of poor policy design and/or implementation. In addition, careful consideration of any equity or consequences of the intervention is also important, for ethical reasons and for gaining political trust.

6.7 LIMITATIONS AND FURTHER STUDY

Section 1.6 of this thesis has already projected some views on the delimitation of this study. By the time of completing this study, there are clear limitations identified and further studies required. The strength of this study lies in its comprehensiveness, its re-checking of established theories, and its testing of new hypotheses with data collected from industry. Although three analyses – a game theoretic model, interviews, and a questionnaire survey – have been conducted reasonably well in this study, the work's strength is also its potential weakness. The resources for a PhD study have been spread thin to cover these three areas of analysis. The game model, with its many mathematical equations, has the potential to be challenged for being too complicated or based on wrong assumptions. The interviews with 15 top executives of development companies or professional consultancy firms provide valid data, but they could have covered a wider range of professionals and included the views of members of the public as end-users. BEE being relatively new to industry also poses problems for the interview process in that some of the questions may not have been fully understood by the interviewees. To overcome this problem, more time could have been allowed for talking

to the interviewees in advance and, if possible, in running a small group briefing session for potential interviewees through some of the academic seminars. This would have ensured that all those being interviewed had a certain degree of knowledge.

To conduct a cross-national survey is very expensive and time consuming, and in conducting the surveys in Hong Kong and Singapore, I was very fortunate to have the support of BCI, which provided its already-collected data from the questionnaire survey. The survey was carried out with most of the architects practicing in Hong Kong and Singapore who have contact with BCI. In future in-depth studies on this focused topic, it would be better to have governmental support for a more comprehensive study with a larger pool of target groups and a wider range of market players, including engineers, project managers, and client organizations.

This work provides a wide but sound platform for future research. The long list of discussion points in this chapter provides good food for thought for those venturing into new studies. In particular, this study has identified several incentives to help promote BEE. However, the incentives should be thoroughly investigated to ascertain market conditions and stakeholders' concerns to ensure their maximal effectiveness. This will be an area of fertile ground for further in-depth research.

6.8 CONCLUSIONS

This study has adopted a holistic approach to studying the barriers to BEE investments and has focused on transaction costs in particular. It provides a review of diverse literatures, including those on building energy efficiency, transaction costs, real estate development, and game models. This research has comprehensively analyzed the market barriers to BEE from the perspectives of the developers, the end-users, and the government. The research design employed three research methods: game theoretic modeling, an interview survey, and a questionnaire survey. The game model has verified some of the TCE theories that apply to the BEE market. The interview survey has provided very rich data from discussions with top-level practitioners and executives of development companies. The data provides a long list of findings and a valid test of the

hypotheses as they apply to the case of the Hong Kong BEE real estate development. The questionnaire, though only covering Singapore and Hong Kong, has provided an overall picture of the barriers in a BEE market with an Asian culture and business environment. Triangulating is the best method for combining the findings from the three areas of analysis and helps pinpoint the focus for discussions. It has also led to the development of the recommendations in Chapter 6. The literature review permits a solid understanding of the role of government and potential policy instruments and incentives. Finally, based on the findings of this study and ideas located in the literature review, the final chapter of this thesis presents some recommendations for policy innovations to address barriers to BEE investment.

The overall findings are significant to the implementation of BEE for the following reasons. The findings include both empirical and theoretical results, which came from original analysis and cross referencing to draw the conclusions. These findings have gone through a thorough understanding of BEE market, and most parts have been published in journals after a vigorous review process. The results from the thesis will definitely help understand the real market concerns in terms of transaction costs during the whole real estate development process. It helps the policy makers to understand when, to whom, where, and how to design the policies that are in favor to the real need of the market. It, therefore, ensures the success of BEE implementation.

APPENDICES

Appendix 3.1: Architect's outline plan of work in real estate development (in concern of traditional buildings) (Copy of the RIBA Outline Plan of Work, italics texts are interpretations from the RIBA Job Book)

Stage			Purpose of work and Decisions to be reached	Tasks to be done	People directly involved
Briefing	A	Inception	To prepare general outline of requirements and plan future action.	Set up client organization for briefing. Consider requirements, appoint architect.	All client interests, architect.
	B	Feasibility	To provide the client with an appraisal and recommendation in order that he may determine the form in which the project is to proceed, ensuring that it is feasible, functionally, technically and financially.	Carry out studies of user requirements, site conditions, planning, design, and cost, etc., as necessary to reach decisions.	Clients' representatives, architects, engineers, and QS according to nature of project.
Sketch Plans	C	Outline proposals	To determine general approach to layout, design and construction in order to obtain authoritative approval of the client on the outline proposals and accompanying report.	Develop the brief further. Carry out studies on user requirements, technical problems, planning, design and costs, as necessary to reach decisions,	All client interests, architects, engineers, QS and specialists and all statutory and other approving authorities.
	D	Scheme Design	To complete the brief and decide on particular proposals, including planning arrangement appearance, constructional method, outline specification, and cost, and to obtain all approvals.	Final development of the brief, full design of the project by architect, preliminary design by engineers, preparation cost plan and full explanatory report. Submission of proposals for all approvals.	Architects, QS, engineers and specialists, contractor (if appointed).
Working Drawings	E	Detail Design	To obtain final decision on every matter related to design, specification, construction and cost.	Full design of every part and component of the building by collaboration of all concerned. Completer cost checking of designs,	Architects, QS, engineers and specialists, contractor (if appointed).
	F	Production Information	To prepare production Information and make final detailed decisions to carry out work.	Preparation of final production information i.e. drawings, schedules and specifications.	Architects, engineers and specialists, contractor (if appointed).
	G	Bills of Quantities	To prepare and complete all information and arrangements for obtaining tender.	Preparation of Bill of Quantities and tender documents.	Architects, QS, contractor (if appointed).
	H	Tender Action	*To select the most competitive tender and award the tender*	*Compile a list of tenderers* *Issue tender documents* *Check and open tenders*	Architects, QS, engineers, contractor, clients.
Site Operations	J	Project Planning	*To award the contract to the selected tender and brief all personnel involved of the project information and requirements*	*Notify acceptance of tender* *Check all contract document are in order* *Brief all project personnel of the project requirement and procedure for administer the project*	Contractor, sub-contractors.

				Check approvals and site condition to ensure the project can be carried out on site	
	K	Operations on Site	*To ensure the project are constructed on site as approved plans and service installations are running properly*	*Sitting out the building on site* *Site meetings* *Supervision and site visits* *Financial monitoring of each construction stages* *Testing and Commissioning of service installations* *Prepare maintenance manual*	Architects, engineers, contractors, sub-contractors, QS, client.
	L	Completion	*To handover building and prepare final account and certification*	*Check works ready for completion* *Hand-over inspection* *Rectify defects* *Final inspection and final certificate*	Architects, engineers, contractor, QS, client.
Feedback &	M	Feedback	To analyze the management, construction and performance of the project	Analysis of job records. Inspections of competed buildings. Studies of building in use.	Architects, engineers, QS, contractor, client.

Appendix 5.I – Sample of Interview Questions

The aim of this interview is to investigate the concerns (in terms of transaction costs) of Developer in participating in Green Building (energy efficiency) Investment.

For this interview, you may refer to "green building" with reference to, but higher than a standard one required by the local labeling scheme, e.g. HKBEAM, or LEED.

Proposed hypotheses and research questions

1. **specific investment**

H1: By dividing the transaction in the whole real estate development (RED) process into smaller established stages, it helps the government better understand/make policies with more focused emphasis on the different stages of transaction to promote BEE more efficiently with appropriate policies.

Q1: Which are the most concerned stages to the developers in the real estate development process?

(Refer to the Table "Outline plan of extra work and transaction costs in RED": answer the questions in the column 2 (Extra tasks to be done) to indicate the developer's level of concerns in each of the suggested items)

Q2: What will be the reason that developers are willing to accept / afford the new appliance/ technology without the incentives from government? How much price difference (in term of % of the total development cost) would they accept?

Q3: Uneven emphasis for incentives: What kind of facilities/building elements is more expensive or difficult to be retrofitted later if not installed in a new project? Should those facilities/building elements that are more expensive/ difficult to be retrofitted should be emphasized in any incentives to promote BEE investment. Why?

Q4: For developers investing in BEE, what are their concern differences between investing in luxury buildings and in lower price buildings? Why?

Q5: For BEE projects, there is a misplaced benefit between the people who pay and the people who gain the benefit in BEE. To address this problem, would rental or selling price difference for BEE building and non-BEE ones help? Any other means help to address the misplaced benefit?

2. **frequency**

H2: Size of company & transaction costs

Q1: size of the project
Q2: size of the development company
} will it affect the developers' concerns in BEE?

H3: Frequency of BEE investment (regular investor or not) & transaction costs

Q1: How does the frequency of BEE investment of a developer (e.g. regular investor, occasional or at one-go) affect the concerns of the developers on BEE investment?

Q2. Would the developer's concern change if they have been investing in BEE projects more frequently? Why?

3. <u>uncertainty</u>

- <u>economic uncertainty</u>

H4: "Economic changing" (upturn or downturn of economy) taken into consideration

- Developer

Q1: At "economic transition" period/stage (upturn or downturn), what are the new challenges or opportunities to developers in investing in BEE? How would this economic transition period change the trend of developers' major concerns (ongoing, positive or negative) and in which aspects?

(e.g. consider the impact of the economic downhill at the moment to the BEE investment strategy and concerns of developers - How could economic downhill affect the BEE investment?)

Q2: At "economic transition" period/stage (upturn or downturn), how could the developer integrate green features into original investment practice to increase market competitiveness.

- Government

H5: The government should adjust the policy/incentive and meet the changing needs called by developers with the phase of "economic transition" (upturn or downturn).

Q1: What role should the government play on BEE promotion (more intervention or less intervention at the downhill economic)?

During "economic transition" (upturn or downturn), what BEE promotion policy/incentive could government introduce that could have less upset to the market players' normal activities?

(Refer to the 6 typical incentive schemes in the table, rank the preferred incentive scheme for economic downturn and then for downturn situations)

- <u>market uncertainty</u>

Information

H6: The developers might be confused by the end-users' variable expectations on BEE, e.g. they may misinterpret a focused group as the end-users for their final products

End-users' variety

- Occupant's behavioral variety may affect a developer to produce different BEE/GB of different performance. What is your view?
- Social classes (different education level, experience, financial status to appreciate the benefit of BEE). Will it affect the developers' concern in BEE investment?

- <u>policy uncertainty</u>

H7: Stage of policy implementation & transaction costs

Q1 Would the concerns of a developer be different towards a new incentive and a current mature incentive when making decision to invest in GB/BEE?

Encountering a BEE incentive scheme, would a developer have more concerns during the early stage (or during the later stage) of implementation of the incentive scheme. How they are different?

Sample of Interview questions sheet with note-taking

		Hypotheses (H)	Questions (Q)	Notes taking (H↔Q)
Specific investment		**H1** By dividing the transaction in the whole real estate development (RED) process into smaller established stages, it helps the government better understand/make policies with more focused emphasis on the different stages of transaction to promote BEE more efficiently with appropriate policies.	**Q1**Which are the most concerned stages to the developers in the RED process?	
			Q2What are the reasons developers willing to afford the new appliance/ technology without government incentives? What price difference (% of development cost) would be accepted?	
			Q3Uneven emphasis for incentives: What facilities/building elements are more expensive/ difficult to be retrofitted later if not installed at first place? Should they be emphasized in incentives to promote BEE investment?	
			Q4For developers investing in BEE, what are their concern differences between investing in luxury buildings and in lower price buildings? Why?	
			Q5There is misplaced benefit between the people who pay and who gain from BEE. To address this problem, would rental/ selling price difference helps?	
Frequency		**H2** There is a positive relationship between the size of the company & the transaction costs incurred in developing BEE projects.	**Q6**Will the size of the project affect the developers' concerns on BEE investment?	
			Q7Will the size of the RED company affect the developers' concern on BEE investment?	
		H3 There is a positive relationship between the frequency of the BEE investment and the transaction costs (concerns) incurred in developing BEE projects.	**Q8**How does the frequency of BEE investment of a developer (e.g. regular investor, occasional or at one-go) affect their concerns on BEE investment?	
			Q9Would the developer's concern change if they invest in BEE projects more frequently? Why?	
Uncertainty	Economic	**H4** The economic transition (upturn, downturn) affects the concerns of the real estate developers on BEE investment.	**Q10** At "economic transition" period/stage (upturn or downturn), what are the new challenges or opportunities to developers in investing BEE? How would this economic transition change the trend of developers' major concerns (neutral, positive or negative) and in which aspects?	
			Q11 At "economic transition" period/stage (upturn or downturn), how could the developer integrate green features into original investment practice to increase market competitiveness.	
		H5The economic transition (upturn, downturn) call for the attention to the government to adjust the BEE policies accordingly to seize the BEE development opportunities.	**Q12**What role should the government play on BEE promotion (more intervention or less intervention at the downhill economic)?	
			Q13 During "economic transition" (upturn or downturn), what BEE promotion policy/incentive could government introduce that have less upsetting to the market players' normal activities?	
	Market	**H6** The end-users' variable expectations on BEE increase the market uncertainty to the developers, e.g. they may misinterpret a focused group as the end-users for their final products.	**Q14**Occupant's behavioral variety may affect developers to produce different BEE/GB of different performance. What is your view?	
			Q15 Social classes (different education level, experience, financial status to appreciate the benefit of BEE). Will it affect the developers' concern in BEE investment?	
	Policy	**H7** The earlier the stage of BEE policy implementation, the higher concerns in terms of transaction costs incur to the real estate developers.	**Q16**Would the developers concern differently on their decision-making of BEE/GB with a new incentive and a current mature incentive? In other words, encountering BEE incentives, would the developers have more concerns during the early stage (or during the later stage) of implementation of the incentive. How are they different?	

Appendix 6.1: Consolidated Conclusions/Comments from the 3 research methods

Themes	Conclusions/Comments from Game Modeling	Conclusions/Comments from Interview Survey	Conclusions/Comments from Questionnaire Survey
Competition in the BEE Market	• Supply of BEE in a competitive market is bigger than that in a monopoly market, thus, policies from governments should prioritize to break up monopolies and encourage competition, for example in the land market, so as to promote the BEE development from the supply side. • By increasing competition in BEE market, it benefits the end-users from two aspects, one by providing more BEE products, the other by increasing the total consumer surpluses in market. •	• Regarding to the role that government plays during the economic transition, most people agree that "Basically, during the economic up-turn, government incentives or promotion are less effective than the down-turn, because the property sells well and the buyers are less concern about green features. • During the economic downturn, government incentives are more important, because the developers are more reluctant to invest in green and people who buy also need to be more assured by the benefits from green incentives".	• "Rising energy costs", "government regulation/ building code", "lower lifecycle costs of GB" and "worsening environmental conditions" are the main favorable factors to advance the GB development. Without government's moderating role, it could lead to unfair competition.
Uncertainty	• In a BEE market with uncertainties, the developers will develop smaller quantity of BEE products, comparing to a market with complete information. In light of transaction costs occur due to uncertainties, the much severe the uncertainty is, the smaller quantity of BEE they would develop. (Agree) •	• Most people think "more concerns arise during the early stage because more uncertainty". Another big poll (66.7%) to what the government can do better "Based on the international experience/ practice, the government will first take part in the new movement by integrating all their projects with the new features as pilot projects (demonstration projects) and share the experience with the market. After a certain period of time/ few years, they could find out all these worries, they will then mandate the polity to the market". • In general, majority views agree that "For a new incentive, the most concern to the market is if it's stable and long-lasting. Therefore, the more established the less concern, the earlier stage the more challenge."	• Industry rating systems, such as Green Star, LEED, are gaining a wide recognition in GB development. It is surprising to find that "industry rating systems" is not, as would be expected, the main favorable factor that motivate the GB market from the views of building designers. This is not consistent with findings of previous study for Singapore in that the architects allege a lack of consistent, accurate and reliable information about environment for GB design. The ranking result may be attributed to the lack of detailed knowledge and consensus approaches for delivering GB. For example, the lack of detail knowledge about GB rating systems or green concepts may lead to developers' reluctance to rely on the rating systems or invest in GB. An alternative explanation for such a ranking result could be that the building designers may believe there are enough research and effort devoted to develop industry rating systems

			already. Instead of devoting too much resource to develop rating systems, education and sharing of standard approaches for delivering GB are crucial to the successful promotion of been building market.
Incomplete Information	• From the perspective of the whole society, total supply of BEE products would decrease, if the incomplete information or the unfair competition situation worsens the BEE market. It implies the benefits brought by BEE to the welfare of society would decrease accordingly. (Agree) • Therefore, the quantity of BEE products in the new equilibriums would decrease further, showing that incomplete information with unfair competition would undermine the reputation of BEE and jeopardize the long term healthy development of BEE. (Agree) •	• Regarding to the "social classes" that may affect the developers' concern in BEE investment, two equally weighted views have been found: "The rich people in higher social classes will appreciate the benefits of BEE better than the low income people, which attract the developers to invest in BEE for high price buildings"; "The higher educated class will appreciate the BEE better, which would contribute towards a better environment". It pinpoints that those people that would be easily motivated by BEE business strategy from the developers, or by the government incentives are those both "rich (affordable)"and "well-educated" people. • Most people believe that Occupant's behavioral variety may affect developers to produce different BEE/GB of different performance. There is a need to have a standard measurement for the building to see whether it's a good performance or not.	• GB, as a new venture to deliver new products, requires higher upfront cost, which is a very obvious obstacle in GB. However, this perception of higher upfront cost might be exaggerated due to the lack of real knowledge of the cost of GB. It is coincident that the factors of "lack of education" and "lack of awareness" are other important obstacles, which are supported by other studies (Chew, 1994; Ganeson, 1996; Ofori & Ho 2004) The factor "no fiscal incentives" is also an important obstacle that hinders the development of GB. Respondents would like to see government intervention to push for a demand for GB. This is what this paper has set out to argue that, apart from government mandatory regulations, incentives are most essential to promote GB market. •
Costs as the major concern	**Hypothesis H2 (GM):** In the Bayesian Cournot game model between the developers with incomplete information, Developer 1, who develops genuine BEE products, will develop smaller quantity of BEE, compare with that would develop in a complete information market, in light of transaction costs may incurred by uncertainties. **Supported**	**Hypothesis H3 (F):** There is a positive relationship between the frequency of the BEE investment and the transaction costs (concerns) incurred in developing BEE projects. **STRONGLY supported**	**Hypothesis B2:** Cost concerns are the major obstacles that hinder investors from entering the GB market. **Supported** "Perceived higher upfront costs" is the undeniable holdback that should arouse attention,
Government intervention	• The equilibrium price of BEE product is dependent on its cost, benefit, as well as the relative bargaining power between the developer and the end-user. • The equilibrium amounts of BEE supply	• Hypothesis H5 (EU): The economic transition (upturn, downturn) call for the attention to the government to adjust the BEE policies accordingly to seize the BEE development opportunities. PARTIALLY Supported	• As set out in our literature review, economic force and government interventions are the strong forces to arouse interests in GB market. Therefore, "rising energy costs" will present such an economic reality that people will have

	and demand are lower than the social optimal level, with externalities considered. Government interventions such as incentives, awareness raising are needed to promote the development of BEE market.	• Most people agree that "Basically, during the economic up-turn, government incentives or promotion are less effective than the down-turn, because the property sells well and the buyers are less concern about green features. During the economic downturn, government incentives are more important, because the developers are more reluctant to invest in green and people who buy also need to be more assured by the benefits from green incentives".	to take part in GB for their own interest. "Government regulations or building code" will create mandatory push for people to take part in GB. "Lower lifecycle cost" is a great economic attractions for all stakeholders in society to be involved. These three factors are ranked the highest on the issue- favorable factors. Government is expected to do more in this role. However, it is noticed that the benefit to the building-users or the employees, such as "higher tenant satisfaction and productivity in GB", is the least favorable factors of concerns of the building designers. It echoes the discussion that the issues directly related to cost and benefit are the major attraction to the business world. This is not a positive mind-set to be encouraged for the overall benefit of society. • The result also indicates that the market challenges for GB are mainly due to the lack of economic and advocatory incentives from the government.
Government intervention at what stage		• **Hypothesis H7** (PU): • The earlier the stage of BEE policy implementation, the higher concerns in terms of transaction costs incur to the real estate developers. **Supported** • The key conclusions are that during the early period (Briefing stages) of a BEE project development, there are more extra tasks involved than other stages.	
Government to provide level playing field	**Hypothesis H1 (GM):** 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. **Support**		
Policy	• As for the government, it is crucial to	Address the risks (TC) concerns at the following	The following are recommended directions to

packages (Incentive)	have long term strategies and clear policy signals for BEE promotion, in order to create a positive investment environment and raise the stakeholders' confidence and market expectation for business investment in BEE. For example, the governments should formulate and implement a package of polices by taking into consideration of the transaction costs impacts to the market stakeholders. • The possible policies includes unveiling the road map of energy and carbon taxes reform, ensuring the future business attraction of BEE products by setting up a reasonable energy prices, raising up the awareness of BEE by advocating and educating the public the urgency and importance in this matter, and setting up incentive schemes to reduce the costs for developers and end-users, etc.	identified stage: • The key conclusions are that during the early period (Briefing stages) of a BEE project development, there are more extra tasks involved than other stages. The most concerned area is consideration of extra legal liability risk of the BEE product. The other risk items are mainly relating to extra study and knowledge about the market. • At sketch plan stage, the top high risk task is cost study for using new design features and exploring special technical solution. • At working drawing stage, the high risk item is looking for suitable contractor. • At Site operation stage, generally, the risk concern is getting less. Opinions are diverse and "Extra requirement on Testing and Commissioning" is the top high risk item, which deal with new knowledge again. • Feedback and Maintenance stage, the risks are general standard. The highly concern items are mostly related to marketing and leasing. Generally, this stage does not attract too many extra task or risk concern.	improve policy decision-making on GB market: (a) Government's direct intervention is required to moderate energy price relating to building thus to make energy efficient building a worthwhile effort and a profitable business. (b) Government should impose some basic mandatory requirements to regulate the quality standards of GB. Such move will deter opportunistic behaviour of the stakeholders in an asymmetry information market and create a level playing field for all competitors of the GB market. (c) Government should help the industry to develop technology and know-how /knowledge for GB to be delivered at a lower initial cost and operated with low life-cycle cost. (d) Government's helps to the industry could be provided through economic incentive schemes. (e) The underlying value, long-term cost benefits and inherent contribution to society of GB should be clearly and widely promulgated to consumers. Their awareness and need for GB will create a demand market. For dense cities such as Hong Kong and Singapore, citizens' aspiration for habitable space is biased with focus on the size of floor area only, without many considerations given to the quality of space and environment. This concept has to be changed to be in line with the growing concept of sustainability. (f) Education and awareness champions are always the welcomed means for continuous promotion of a GB market. These tasks could be shared by professional institutes, NGO's and government bodies.

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