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**Master of Science in Engineering**

**Validity Evaluation  
of Boosting Policies for G-SEED  
on Housing Market**

**by**

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The Graduate School

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February 2016

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of the requirements for the degree of  
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## **Abstract**

# **Validity Evaluation of Boosting Policies for G-SEED on Housing Market**

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Since 2002, Korea Government has implemented G-SEED(Green Standard for Energy and Environmental Design) certification for reducing GHG emission in building area. However, total number of G-SEED Certification is only around 1% of total number of approved apartment buildings despite the various boosting policies. In this situation, most boosting policies and policy improvement researches are leaning toward the supplier's aspect. However, comprehensive relation and dynamics between consumer and supplier has to be considered since housing market is operated by market participants' mutual interaction. Therefore, this research presents system

dynamics models based on decision-making analysis of consumer and supplier in G-SEED certified apartment building market. Then, this research evaluates the validity of boosting policies using the model. The proposed analysis can assist government to make next boosting policies for G-SEED certification.

**Keywords: G-SEED, Incentives, Apartment Building, System Dynamics**

**Student Number: 2014-20508**

# Contents

Chapter 1	Introduction .....	1
1.1	Research Background and Objectives .....	1
1.2	Research Scope and Process .....	5
Chapter 2	Preliminary Study .....	7
2.1	G-SEED Certification .....	7
2.2	Boosting Policies and the Effects .....	10
2.3	Demand and Supply Structure of Housing Market.....	12
2.4	System Dynamics .....	14
2.5	Summary .....	16
Chapter 3	Model Development .....	17
3.1	Demand Model of G-SEED Certified Housing .....	19
3.2	Supply Model of G-SEED Certified Housing .....	22
3.3	Demand and Supply Integrated Model of G-SEED Certified Housing .....	26
3.4	Summary .....	31
Chapter 4	Effects Analysis of Boosting Policies .....	32
4.1	G-SEED Boosting Policies for Supplier .....	36
4.2	G-SEED Boosting Policies for Consumer .....	38
4.3	Summary .....	39

Chapter 5	Conclusions.....	40
5.1	Results and Discussions.....	40
5.2	Contributions, Limitations and Further Studies.....	42
Reference.....		43
Abstract (Korean) .....		50

## **List of Tables**

Table 1-1 Biased View of Previous Researches .....	4
Table 2-1 Changes in Boosting Policies for G-SEED Certification.....	11
Table 4-1 Boosting Policies for G-SEED Certification.....	33
Table 4-2 Causal Relationship by Boosting Policies.....	35



## List of Figures

Figure 1-1 Trend Comparison between LEED and G-SEED .....	2
Figure 1-2 Research Process .....	6
Figure 2-1 Diagram of System Dynamics.....	14
Figure 3-1 Conceptual Structure of Demand and Supply Model.....	18
Figure 3-2 Decrease in Demand due to Certification Additional Cost..	19
Figure 3-3 Demand Change according to Relative Utility.....	20
Figure 3-4 Increase in Demand due to Favorable Image Formation ...	21
Figure 3-5 Decrease in Supply due to Additional Cost.....	23
Figure 3-6 Increase in Sales Price due to Favorable Image Formation ..	23
Figure 3-7 Property Value Improvement due to Favorable Image Formation .....	25
Figure 3-8 Self-Regulation Effect of Sales Price and Demand and Supply Reference Mode .....	28
Figure 3-9 Demand and Supply Integrated Model of G-SEED Certification Apartment Housing Market .....	29
Figure 4-1 Effects of Boosting Policies for G-SEED Certification .....	32

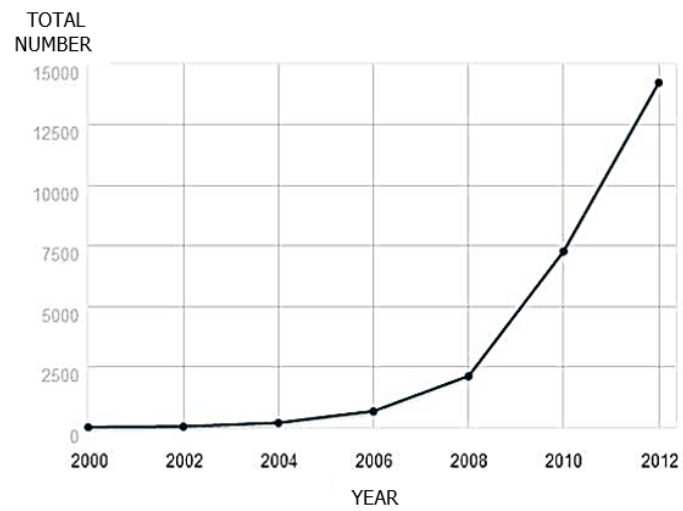
# **Chapter 1. Introduction**

## **1.1 Research Background and Objectives**

As global warming is accelerated, there have been many efforts to reduce GHG gas emission globally. In order to reduce GHG gas emission in construction area, some developed countries such as U.S.A, Germany and Great Britain have introduced green building certification reported to be very effective to GHG gas reduction(Yeom 2013). South Korea also has adopted similar certification called G-SEED (Green Standard for Energy and Environmental Design) from 2002.

LEED (Leadership in Energy and Environment Design), US environmental building certification system has shown continuous annual growth rate over 70% since it has been first implemented in 2000(USGBC 2015). However, even after more than 10 years it has been started and various boosting policies by the government, total certification numbers in apartment building area is still around 1% of total approved apartment building numbers(G-SEED Certification Integrated Operation System 2015). Furthermore, when it comes to the trend pattern it shows that not a continuous increasing pattern as LEED but a repeated rising and falling pattern(Figure 1-1).

## LEED



Brett Molina(2013), USA TODAY

## G-SEED

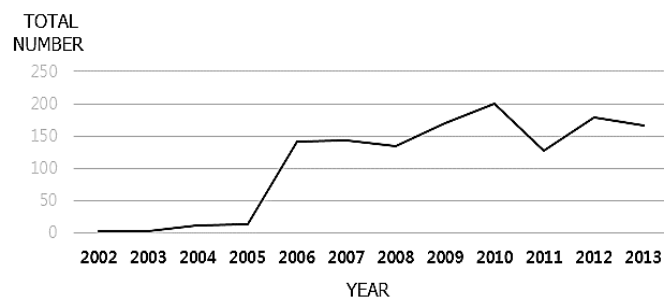


Figure 1-1 Trend Comparison between LEED and G-SEED

Korea Institute of Construction Technology(2009) suggested methods to improve the certification system. These are to make easier acquisition and additional incentives mostly focused on the supplier for boosting G-SEED. Choi(2010) claimed that political support to suppliers is needed emphasizing the importance of their role. Such studies carry an important meaning since it made a counter-offer by analyzing the certification housing market problem. However, they also have limits and these are primarily concentrated in supplier side(Table 1-1). Also, most boosting policies of the government conducted up to now are intended for suppliers.

It is necessary that housing market be analyzed focused on the comprehensive relationship and dynamics rather than the biased viewpoint because the market are operated with participants affecting each other. This research finds out the mutual relationship between consumer and supplier by creating a demand and supply system dynamics model of green building certification apartment which is formed from decision-making of the consumer and the supplier. Thereafter, the elements of green building certification boosting policies of the government are applied on the model. These elements are to be analyzed to find out how the policies make changes to demand and supply, and whether these make number of green building certification increase in the end or not.

The objective of this research is to find out the reasons why G-SEED certification rate is low by presenting decision-making process of certified housing market's participants and analyzing the process using system dynamics method.

Table. 1-1 Biased View of Previous Researches

Researcher	Subject		Contents
	Supplier	Consumer	
Kim et al. 2007	o	x	Analysis of current incentives' application and compare existing one and proposed one. The result from poll is that supplier has been more interested in proposed one and this means current one is not effective.
Korea Institute of Construction Technology 2009	o	x	Propose the following incentives: Mitigation of building standard, reduction of environmental improvement charges and acquisition tax. Suggest improved green building operating system: Establishment of exclusively charged organization for G-SEED etc.
Choi 2010	o	x	Analyze current green policies like G-SEED for improving green building and claim that the political support to suppliers is highly needed due to they are the actual participants of the construction market.
Choi 2010	o	x	Prove that when floor area ratio mitigation incentive is applied, supplier could not get actual profit. Some grade show minus profit. Furthermore, other areas except Seoul have also no profit. Suggest incentive ratio adjustment according to the area.

## 1.2 Research Scope and Process

This research is limited in apartment building area account for 36% of total energy consumption and is only focused on decision-making process of consumer and supplier even though the market includes many other participants. In fact, there are also important and salient factors affecting supply and demand in housing market which are preferable school districts, region and adjacent to public transportation. However, this research excludes the factors and only focus on the influences of G-SEED certification.

The process for this research is the following:

- (1) Learning about G-SEED certification by literature review
- (2) Finding out how the features of G-SEED certified apartment buildings affect decision-making of consumer and supplier
- (3) Developing the causal relation of the factors that lead to decision-making of consumer and supplier using system dynamics method.
- (4) Validating the effects of boosting policies for G-SEED certification based on the system dynamics model.

The flow diagram of research process is shown in the following Figure 1-2.

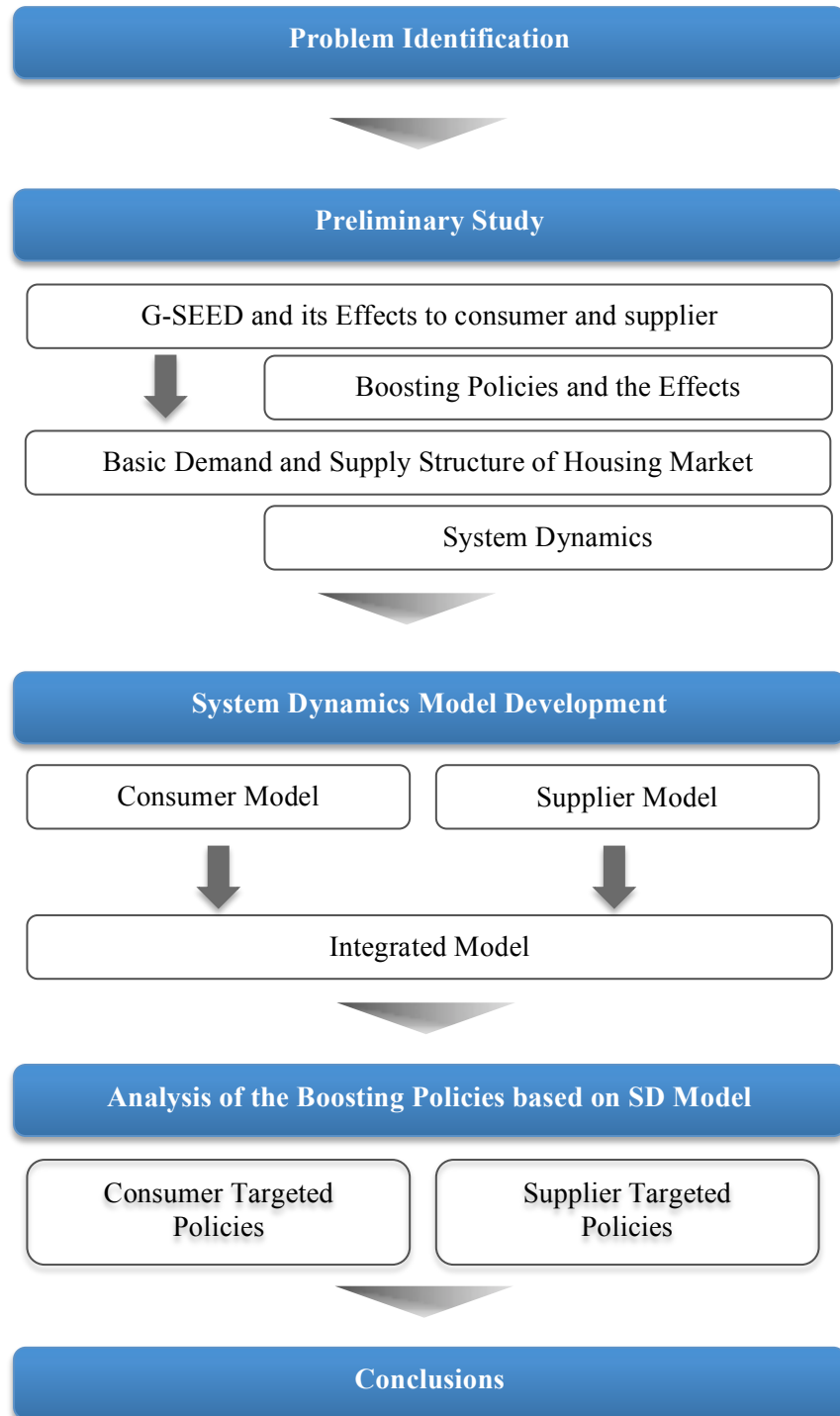


Figure 1-2 Research Process

## **Chapter 2. Preliminary Study**

### **2.1 G-SEED Certification**

G-SEED certification has been implemented to realize sustainable development and induce buildings that are eco-friendly and resource conserved type(Green building improving law, Article 16).

#### **2.1.1 Effects to Consumer**

Living in G-SEED certified buildings results in tenants' health and productivity improvement due to designing nature ventilation and using products emitting low indoor air pollutants such as VOC-zero paint for getting scores of indoor environment part(Cho 2013). Furthermore, tenants could save maintenance costs such as electricity and water bill about 8~9% steadily due to the following factors: Installation of high-efficiency air-conditioning system, water-saving faucet or toilet and waste-water reuse system (Jonathon W. and MaryEllen C. N. 2014). However, increased construction cost for acquiring G-SEED certification makes sales price higher which is a burden on consumer.

Most previous studies about G-SEED certification targeting consumer dealt attractiveness and satisfaction of consumer about certified apartment buildings. Lee and Choi(2012) analyzed that consumers consider G-SEED certified apartment building as a high-quality premium brand because G-



SEED name itself has eco-friendly image. Lee and Shin(2009) also showed the results that consumers recognize certified buildings as better quality buildings and could pay more than the other.

### **2.1.2 Effects to Supplier**

The reason why green building certification is prevalent in developed countries as USA and United Britain is many companies or building owners judge the certification improves their companies' or buildings' image. And these indirect effects could raise their market value(Schmitz A. and Deborah. L B 2012). Actually, many domestic and foreign companies like NAVER and Hearst Corporation adopted green building certification when they build headquarters and utilize it as public relations since they could raise their companies' image as eco-friendly companies. Furthermore, green building certified buildings' value, rate of return on investment and occupancy rate are also increased as 7.5%, 6.6% and 3.5% respectively(Shin 2013). On the other hand, as mentioned above, various additional costs such as construction cost and certification fee are occurred. And these inevitable additional costs act key factors to deprive the certification will of supplier whose goal is maximized profit(Lee et al. 2014).

In this situation, there are many researches to analyze project feasibility and economical feasibility of G-SEED certified apartments. Kang and Yeo(2014) proved that G-SEED certification has positive effects to form apartment price and urge the government to give supports(e.g. various incentives) to boost G-SEED certification. Lee et al.(2011) analyzed the

positive correlation between G-SEED certification and the market price per area. Kim et al.(2007) studied the incentives for G-SEED certified buildings and argued that more supporting policies are required to boost G-SEED certification.

## **2.2 Boosting Policies and the Effects**

The government has introduced various policies from 2006, since the certification rate was too low from 2002 to 2005 when the certification was operated just by market function without intervention of the government. Table 2-1. shows the government's policies for boosting G-SEED certification. Most beneficiary of the policies are biased to supplier and it is mandatory only to public project delivery.

It is found that the certification number was greatly increased from 13 cases to 142 cases as 'Sales Price Cap'(3% of basic construction cost could be added to sales price) has been implemented from 2006. This was figured out from statistics about the annual approved apartment number and G-SEED certified number of it.

Table. 2-1 Changes in Boosting Policies for G-SEED Certification

Year	Related Law	Policy	Target
2006	Rules on Housing Supply (주택공급에 관한 규칙)	Sales Price Cap: 3% addition (분양가 상한제 3% 가산)	Supplier
2007	Additional Cost Standard in Quality Improvement of Apartment (주택품질 향상 에 따른 가산비용 기준)	Sales Price Cap: 1~4% addition (분양가 상한제 1~4% 가산)	Supplier
	Seoul Green Building Standard (서울시 친환경 건축기준)	Additional Points for Prequalification (입찰참가자격 사전심사 가산점)	Supplier
		Supporting for Certification Cost 50~100% (인증비용지원 50~100%)	Supplier
		Supporting for Certification Sign (인증표지지원)	Supplier
		Reduction of Acquisition (취등록세 경감 5~15%)	Consumer
	Daejeon Metropolitan City Guidelines of Built Environment Renewal Development (대전광역시 도시 및 주거환경정비기본계획 운영관리지침)	Mitigation of Building Standard(Floor Space Index) (건축기준 용적률 완화)	Supplier
2011	Green Building Certification Standard (친환경건축물 인증기준)	Mandatory for Architecture more than 10,000 m <sup>2</sup> Gloss Floor Area Implemented by Public Institution (연면적 1 만m <sup>2</sup> 이상 공공기관 시행 건축물 의무)	-
2012	Seoul Green Building Standard (서울시 친환경 건축기준)	Mitigation of Building Standard(Floor Space Index, Height, Landscaping Area) 4~12% (건축기준 용적률, 건축물 높이, 조경면적 완화 4~12%)	Supplier
		Reduction of Property Tax (재산세 경감 3~15%)	Consumer
2013	Green Building Certification Standard (녹색건축물 인증기준)	Mandatory for Architecture more than 10,000 m <sup>2</sup> Gloss Floor Area Implemented by Public Institution (연면적 1 만m <sup>2</sup> 이상 공공기관 시행 건축물 의무)	-

## **2.3 Demand and Supply Structure of Housing Market**

The housing problem could be analyzed with basic concept of demand and supply in common with economical problems(Lee 1997). The consumers pursue utility maximization when they buy housing and the suppliers like housing constructor pursue profit maximization on housing market when they build and supply housing. And housing demand and supply are decided by their decision-making, and housing sales price is determined by time function from these two differences (difference of the demand and supply)(Whang 2010).

Housing demand is set by diverse variables. One of them is the intention of housing purchase: Motivation of residence and purchase(e.g. improvement of housing quality), motivation of asset and investment(e.g. alternative investment income). Another factor is affecting purchase ability: Housing price level and other factor is that influencing ability of loan repayment: Income level. In case of housing supply, there are more simple variables than demand: Housing prices, housing construction costs and available sites that equivalent for the purpose of the supplier, maximization of profit(Lee1997).

If supplier could be survived in today's housing market that has been changed from supplier centered to consumer centered, supplier need to know about future housing demand exactly and predict the change of market structure(Korea National Housing Corporation Housing Lab 1998). Therefore, there are many efforts to develop highly competitive housing products satisfying various requirements of consumer by differentiating image and

brand. Green housing(G-SEED certified housing) which is offered recently for meeting the well-being trend is a representative example.

On the other hand, substitutes refer to the similar products in facility because its purposes are almost same. In housing market, apartment building and single-family homes are substitutes each other due to its purpose is same. With a similar meaning, in apartment housing market, G-SEED certified apartment and non G-SEED certified housing could be called mutual substitutes. When it comes these relationship, if substitutes price is higher, its demand would be decreased which trigger increasing of opponents' demand relatively. In other words, when consumer choose lower priced non G-SEED certified housing, supplier could face difficulties since the unsold-rate of G-SEED certified housing is increased because of dropped G-SEED certified demand.

## 2.4 System Dynamics

System dynamics is one of prevalent modeling methods to suggest analytical solutions for nonlinear phenomena such as social, economic, industrial and environmental problems. This research uses system dynamics because of its effectiveness for analyzing complicated system. The main diagram of system dynamics is as Figure 2-1.



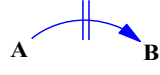
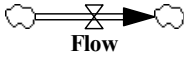



Diagram	Explanation	
	When all other conditions are identical	When Factor A increases (decreases), Factor B increases (decreases)
		When Factor A increases (decreases), Factor B decreases (increases)
	Including weighted delayed time between two factors	
	Flows : Define the rate of change in system states and control quantities flowing into and out of stocks, also called 'Rates'	
	Stocks : Define the state of a system and represent stored quantities, also called 'Levels'	
	Positive feedback or self-reinforcing loop	
	Negative feedback or self-balancing loop	

Figure 2-1. Diagram of System Dynamics (Sterman 2000)

Basically, system dynamics is composed of causality feedback loop and 'Stock-Flow' represents time delay and accumulating process of variables. The causality feedback loop is divided into two loops. The first one is 'Reinforcing loop(R-loop)' makes continuing virtuous or vicious acts and the second one is 'Balancing loop(B-loop)' creates stable situation(Ahmad-Simonovic 2000).



## **2.5 Summary**

This chapter referenced the preliminary study of G-SEED certification and its effects to consumer and supplier respectively. The certification has both pros and cons sides. In case of consumer, various eco-friendly installations for the certification enhance their productivity and reduce maintenance costs. When it comes to supplier, they could improve their images leading to higher profit. Although role of supplier is very important on housing market, the boosting policies skewed towards supplier is considered as a problem since housing market is operated by supplier and consumer together.

System Dynamics has been widely used for complex and complicated problems in various categories. It is also useful to find out variables' relation. With these reasons, the research selected system dynamics method to analyze the housing market and validate the boosting policies.

## Chapter 3. Model Development

This research presents each consumer and supplier causality model and integrated model of them to recognize the relationship between demand and supply and find out the effects of boosting policies. Each consumer and supplier model consists of variables that affect their decision-making when they choose G-SEED certified apartment instead of non-certified one.

Conceptual structure of causality diagram created based on preliminary study is Figure 3-1. Consumer and supplier make decision for their maximized utility and profit respectively. In case of consumers, they would buy G-SEED certified apartment when maintenance cost saving and improvement of living quality(②) is higher than expensive purchase price(①). And supplier would construct and supply G-SEED certified apartment if increased sales rate, price premium and improvement of property value of supplier(④) is higher than increased construction cost(③). In this way, dynamic relation is formed as demand and supply amount that is determined by decision-making of consumer and supplier affects sale price and sales rate and moreover, sales price affects sales rate.

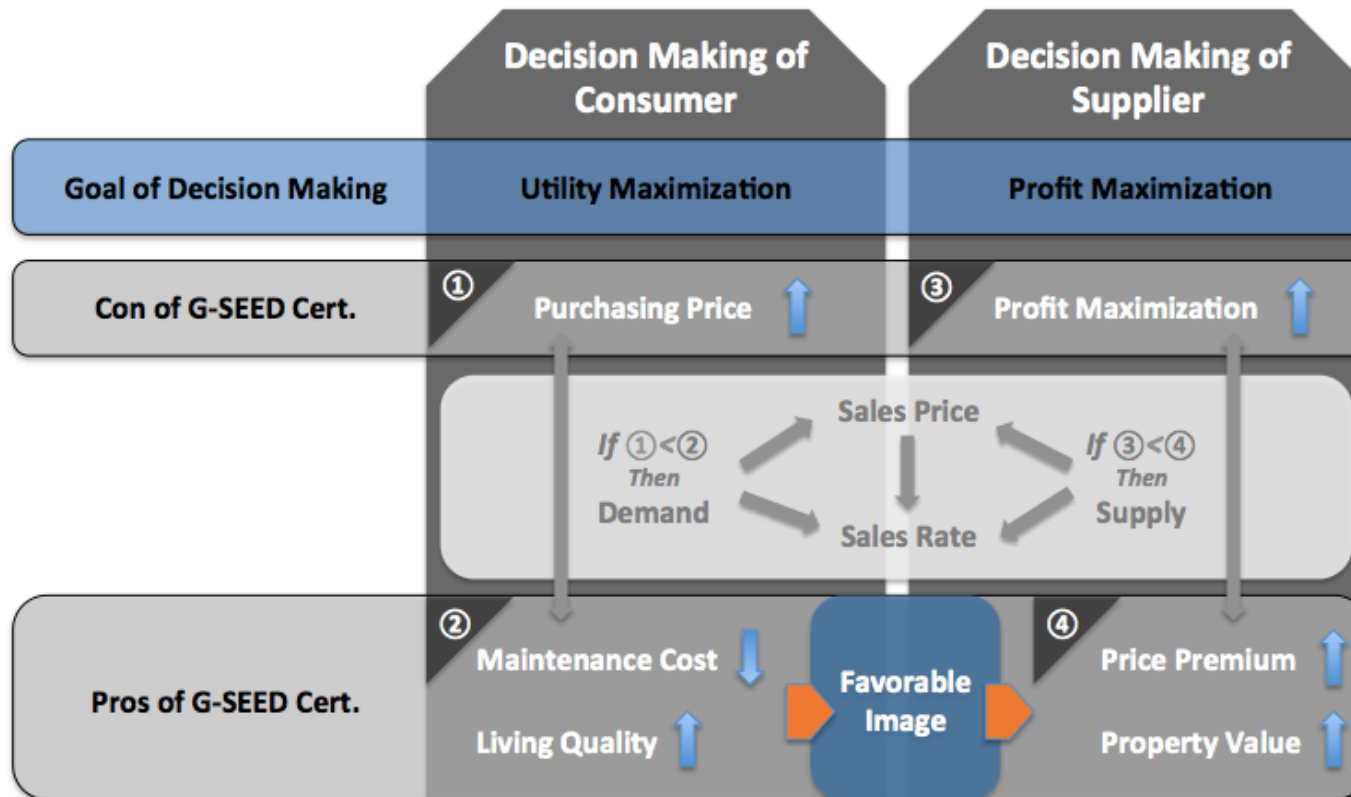


Figure 3-1. Conceptual Structure of Demand and Supply Model

### 3.1 Demand Model of G-SEED Certified Housing

Basically, housing demand could be dealt as a function of ability-to-buy and willing-to-buy. Because housing demand is closely related with pay ability and preference since its concept implies products trading in the market which is same as other products(Lee 1997).

#### 3.1.1 Decrease in Demand due to Certification Additional Cost

Very similar with other goods when housing price is increased, its demand is decreased as well(Whang et al. 2010). Increased ‘Certified Housing Sales Price’ due to ‘Certification Additional Cost’ causes higher ‘Certified Housing Purchase Price’ which results in ‘Certified Housing Demand’ decrease(Figure 3-2).

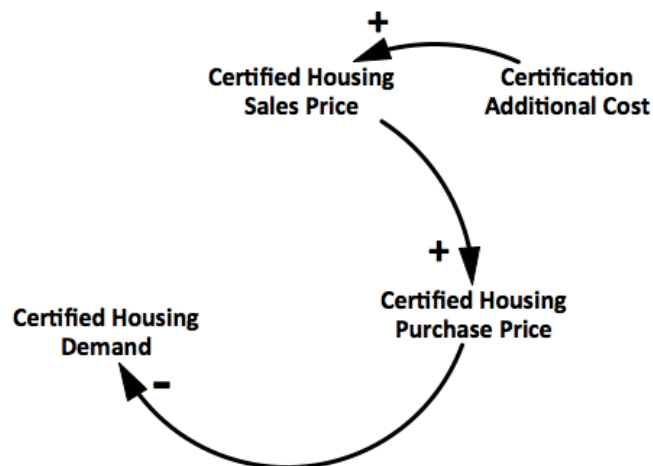


Figure 3-2. Decrease in Demand due to Certification Additional Cost

### 3.1.2 Decrease in Demand due to Certification Additional Cost

Reasonable consumers would buy housing if present value of housing benefit flows(value of housing benefit flows ÷ discount rate) which could be acquired quarterly is perceived more than 'Certified Housing Purchase Price'(Lee 1997). Main benefit of certified housing: maintenance cost could be reduced 8~9% quarterly('Reduction of Cert. Housing Maintenance Cost). Higher 'Perceived Relative Price' means higher 'Perceived Relative Utility by Consumer' causes 'Certified Housing Demand'(Figure 3-3).

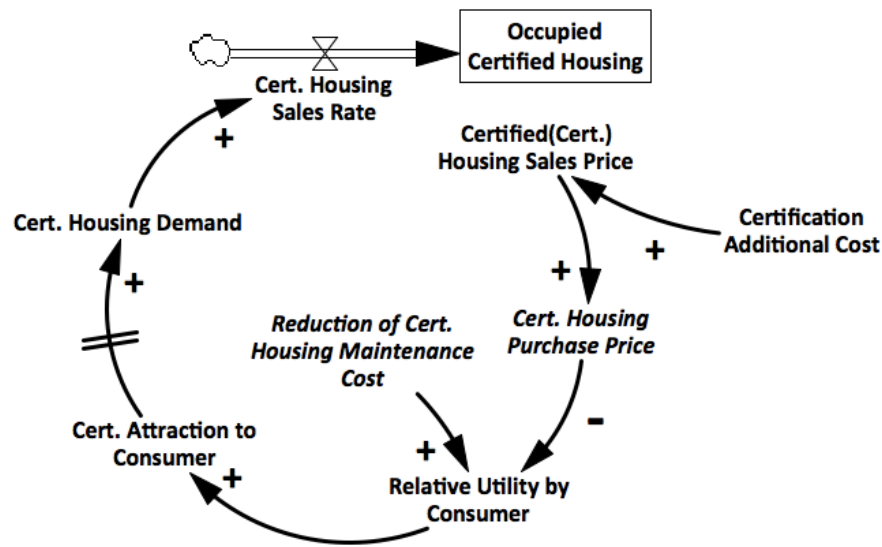


Figure 3-3. Demand Change according to Relative Utility

### 3.1.3 Increase in Demand due to Favorable Image Formation

Consumers make effort to get maximized utility by comparing, analyzing and evaluating many alternatives. The housing quality assessment is difficult before buying and living a house. The risk from uncertainties such as financial, psychological and efficiency called perception risk tend to be relieved by consumer through word of mouth, marketing, brand and price premium of the product at exploration phase(Yoo 2012). High-quality image of certified housing formed from ‘Positive Word of Mouth’, ‘Marketing’ of supplier and ‘Price Premium’ is accumulated as ‘Favorable Image of Certified Housing’. Increased favorable image of certified housing improves ‘Perceived Relative Utility by Consumer’. Subsequently, it creates ‘Certified Housing Demand’ when external factors classified into market condition, related policy and regulatory, geographical condition, area and price are in a best circumstances after some time delay(Choi 2013)(Figure 3-4).

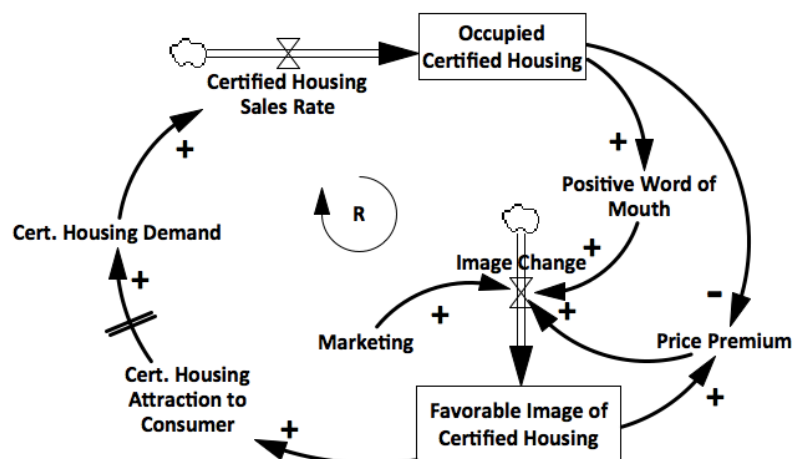


Figure 3-4. Increase in Demand due to Favorable Image Formation

## **3.2 Supply Model of G-SEED Certified Housing**

Housing supply could be divided into new housing and old housing. This research is only concentrated on new housing that is not related to obligations and led by private contractors.

### **3.2.1 Decrease in Supply due to Additional Cost**

As described above, the price of G-SEED certified apartment is higher than non-certified one due to various additional cost(Kim and Kang 2010). Increasing 'Cert. Housing Construction Cost' means decreasing 'Cert. Housing Expected Profit' of supplier that is given when they construct new housing. This makes 'Cert. Housing Supply' lower as dropping 'Cert. Housing Attraction to Supplier' which is compared to non-cert. one. On the other hand, in this research Cert. Housing Supply' is interpreted in the same meaning with the number of the certification because it gives a positive effect on the increase of the certification number. (Figure 3-5).

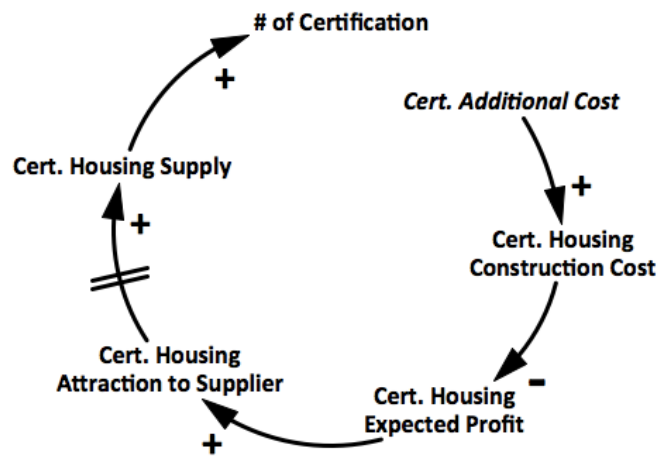


Figure 3-5 Decrease in Supply due to Additional Cost

### 3.2.2 Increase in Sales Price due to Favorable Image Formation

As discussed in chapter 3.1.3, 'Favorable Image of Cert. Housing' makes 'Price Premium' of the Cert. housing and 'Cert. Housing Expected Profit by Supplier' higher. After that it increase 'Cert. Housing Supply' finally (Na et al. 2013) (Figure 3-6).

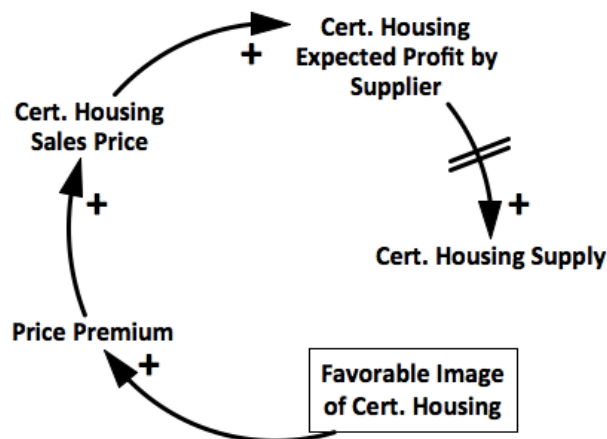


Figure 3-6 Increase in Sales Price due to Favorable Image Formation



### **3.2.3 Property Value Improvement due to Favorable Image**

#### **Formation**

Suppliers could improve their image of companies as eco-friendly companies by supplying G-SEED certified apartments and it means that intangible property value of supplier is increased(Schmitz A. and Deborah. L B 2012). The intangible property value refers to the brand value that has no visible entity but gives substantial value to the company. For instance, the reason why SAMSUNG constructed unprofitable Burj Khalifa in Dubai is the company believed that it improve company's brand value by constructing the tallest building in the world(Yeom 2004). If more certified apartment are supplied, more 'Public Relationship(PR) of Supplier' is increased which lead to 'Favorable Image of Supplier' increasing and then 'Property Value of Supplier' is higher. Property Value affects increasing of supply by hoisting 'Perceived Relative Profit by Supplier' since it is recognized as profit will be appeared in the future(Figure 3-7).

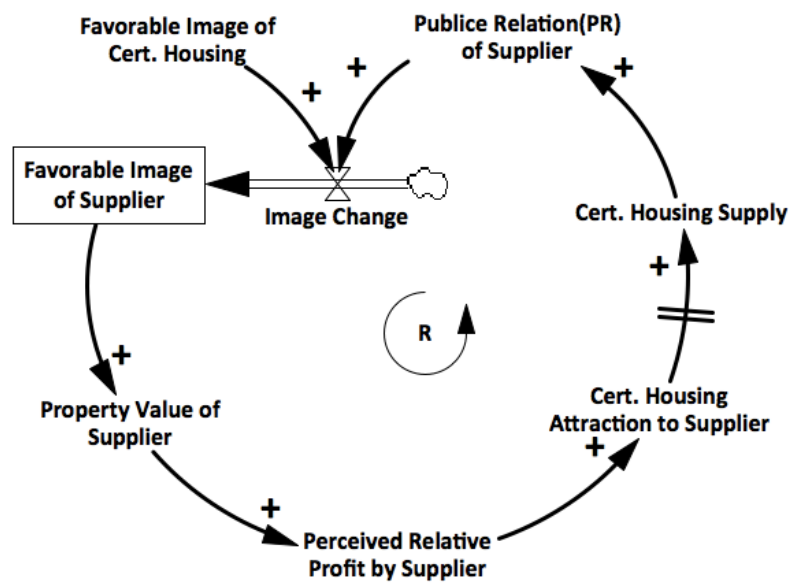


Figure 3-7 Property Value Improvement due to Favorable Image Formation

### **3.3 Demand and Supply Integrated Model of G-SEED**

#### **Certified Housing**

In this chapter, this research finds out integrated and dynamic relationship making demand and supply integrated model Fig. 3-9 based on demand and supply models discussed in chapter 3.1 and 3.2.

#### **3.3.1 Supply, demand and price stability in the market due to the balance**

Increasing of construction cost and purchasing cost due to additional cost for the certification stabilize housing market demoralizing to buy or supply the certified apartments of consumer and supplier. This reaction is determined by the instantaneous without delay(Figure 3-9. Causality relationship from ‘Certification Additional Cost’ to ‘Cert. Housing Demand’ and B-Supply loop).

This could be explained with actual G-SEED certification number transition data. The government expected that the certification market could be activated just by market function without the government’s intervention from 2002(starting point) to 2005. However, certification number in this period is only 2~13(Figure 3-8. Actual Data).

It is possible to infer that expected profit would be decreased because additional cost lower ‘Perceived Relative Profit by Supplier’(Figure 3-9 Causality relationship from ‘Certification Additional Cost’ to ‘Perceived

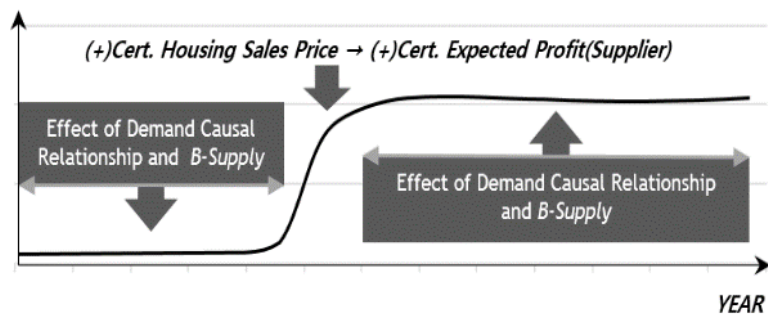
Relative Profit by Supplier’). However, when sales price could be set higher than market price as implementation of ‘Sales Price Cap’ in 2006, the number of the certification has risen greatly over 10 multiples(Figure 3-8. Actual Data).

High sales price influences expected profit of supplier and perceived relative profit increasing which result in certified housing supply rise. On the other hand, high sales price causes purchase price increasing and demand decreasing which result in unsold state. It is expected that B-Supply loop is activated due to lowering expected profit of supplier finally(Figure 3-9).

Figure 3-8 represents causality relationship of consumer part (From ‘Certification Additional Cost’ to ‘Cert. Housing Demand’), reference mode of B-Supply loop effect and actual data, which are very similar to trend. Although supply is restrained by early price, when policies are implemented supply is increased due to rise of suppliers’ expected sales price. However, it could be found the market is stabilized again since B-Supply loop would be activated by increased sales price and decreased demand.

### Reference Mode

# NUMBER of G-SEED Certification



### Actual Data

# NUMBER of G-SEED Certification

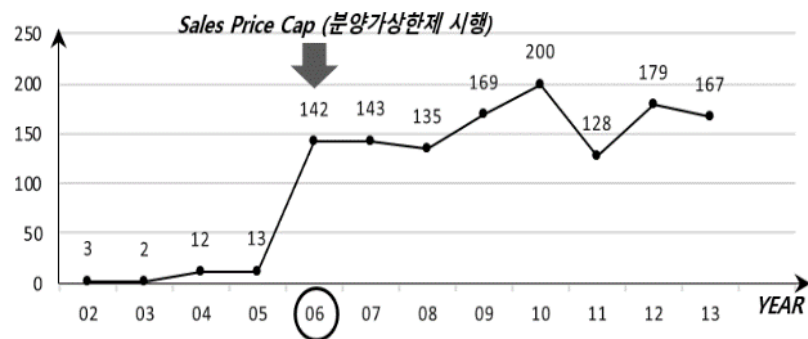


Figure 3-8 Self-Relation Effect of Sales Price  
and Demand-Supply Reference Mode



### **3.3.2 Activation of the Market through Favorable Image**

#### **Formation**

However, demand could be increased by the following sequential process. Favorable image formation from positive word of mouth and marketing make price premium which raise favorable image again and this lower the concern about the risk that consumer could have when they buy apartment. Although short-term effect could not be possible since accumulated certified housing demand that affects word of mouth premises occupied certified housing and a considerable time delay is entailed from favorable image formation to certified housing demand. Furthermore, it takes substantial time for making favorable image of supplier by certified housing supply and increasing of property value of supplier. Therefore, it is expected that short-time effect from the causality is not easy.

### **3.4 Summary**

This research suggests that demand for certified apartment is decided by additional cost, relative utility and favorable image of it. When it comes to supply, key determination factors are increased construction cost, favorable image and good possibility to improve asset value. Short-term or promptly perceived effects tend to lower demand and supply. On the other hand, long-term effect from favorable image makes the housing market actively. In this sense, making favorable image of the certified housing is urgent to increase the number of G-SEED certification.



## Chapter 4. Effects Analysis of Boosting Policies

In this chapter, the research discusses G-SEED boosting policies' effectiveness by finding out the influential relationship of the policies assigned to the integrated system dynamics model that is developed in chapter 3. The government has been implemented various policies to boost G-SEED certification and still valid policies are described in Table 4-1. Figure 4-1 express influence of policies in demand and supply integrated model of Figure 3-9 and Table 4-2 shows the causal relationship with policies.

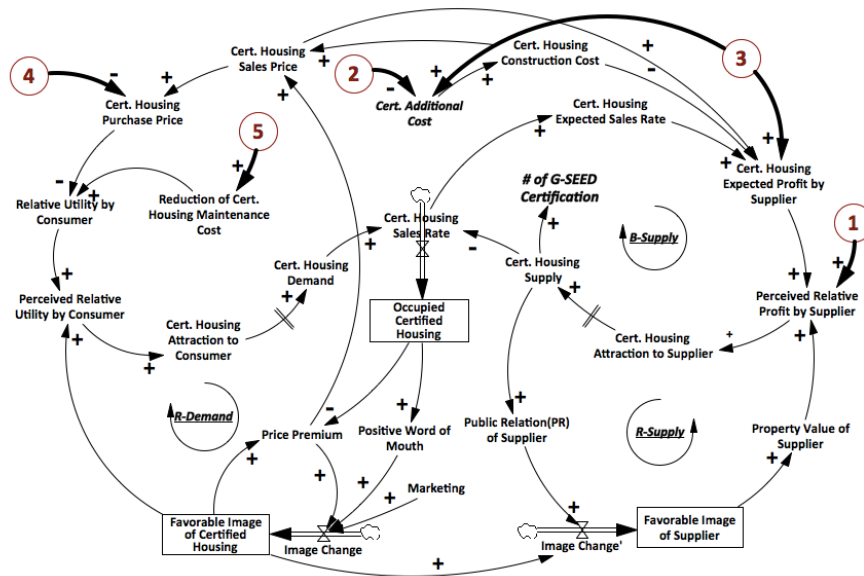


Figure 4-1 Effects of Boosting Policies for G-SEED Certification

Table 4-1 Boosting Policies for G-SEED Certification

Target		Contents	Detail		Source
Supplier	①	Additional Points for Prequalification	•Grant to constructor or designer having G-SEED certification experience		•Seoul Green Building Standard
	②	Supporting for Certification Cost 50~100%	Number of Unit	Maximum Supporting Cost	•Green Building Certification Standard
			Less than 500Units	11,280,000 Won	
			Less than 500~1500Units	13,170,000 Won	
			More than 1500Units	15,590,000 Won	
			Certification Grade	Supporting Ratio	•Seoul Green Building Standard
			Green 1 <sup>st</sup> Grade	100%	
			Green 2 <sup>nd</sup> Grade	80%	
			Green 3 <sup>rd</sup> Grade	70%	
			Green 4 <sup>th</sup> Grade	50%	
		Supporting for Certification Sign	-		
	③	Mitigation of Building Standard(Floor Space Index, Height, Landscaping Area) 4~12%	Energy Standard	G-SEED Certification	•Green Building Supporting Law •Seoul Green Building Standard
				Green 1 <sup>st</sup> Grade	Green 2 <sup>nd</sup> Grade
			Energy Efficiency 1 <sup>st</sup> Grade	12%	8%
			Energy Efficiency 2 <sup>nd</sup> Grade	8%	4%

Target		Contents	Detail				Source	
Consumer	④	Reduction of Acquisition and Registration Tax 5~15%	•Acquisition Tax: One should pay 3.16% of sales price when purchasing new apartment				•Local Tax Law	
			Type	Acquisition Tax	Local Education Tax	Special Tax for Rural area		
			Ratio	2.8%	0.2%	0.2%		
			Energy Standard		G-SEED Certification		•Restriction of Special Taxation Act •Seoul Green Building Standard	
					Green 1 <sup>st</sup> Grade	Green 2 <sup>nd</sup> Grade		
			EPI more than 90points or Energy Efficiency 1 <sup>st</sup> Grade		15%	10%		
			EPI more than 80points & less than 90points or Energy Efficiency 2 <sup>nd</sup> Grade		10%	3%		
	⑤	Reduction of Property Tax 3~15%	•Effective Period : For 5 years after purchase				•Restriction of Special Taxation Act •Seoul Green Building Standard	
			Energy Standard		G-SEED Certification			
					Green 1 <sup>st</sup> Grade	Green 2 <sup>nd</sup> Grade		None Grade
Energy Efficiency 1 <sup>st</sup> Grade			15%	10%	3%			
Energy Efficiency 2 <sup>nd</sup> Grade			10%	3%	-			
None Grade		3%	-	-				

Table 4-2 Causal Relationship by Boosting Policies

Policy		Causal Relationship
①	<b>Additional Points for Prequalification</b>	①→ (+)Perceived Relative Profit by Supplier → (+)Cert. Housing Attraction to Supplier→ (+)Cert. Housing Supply→ (+)# of G-SEED Certification
②	<b>Supporting for Certification Cost and Sign</b>	②→ (-)Cert. Additional Cost→ (+)Cert. Housing Construction Cost→ (+)Cert. Expected Profit by Supplier→ ...→ (+)# of G-SEED Certification
③	<b>Mitigation of Building Standard</b>	③→ (+)Cert. Additional Cost→ (+)Cert. Housing Construction Cost ↓ (-) ③→ (+)Cert. Expected Profit by Supplier→ ... → (+)# of G-SEED Certification
④	<b>Reduction of Acquisition Tax</b>	④→ (-)Cert. Housing Purchase Price→ (+)Relative Utility by Consumer→ (+)Perceived Relative Utility by Consumer→ (+)Cert. Housing Attraction to Consumer→ (+)Cert. Housing Demand→ (+)Cert. Housing Sales Rate→ (+)Cert. Housing Expected Sales Rate→ ...→ (+)# of G-SEED Certification
⑤	<b>Reduction of Property Tax</b>	⑤→ (+)Reduction of Cert. Housing Maintenance Cost→ (+)Relative Utility by Consumer→ (+)Perceived Relative Utility by Consumer→ ...→ (+)Cert. Housing Demand→ ...→ (+)# of G-SEED Certification

## **4.1 G-SEED Boosting Policies for Supplier**

There are three types of policies for supplier: additional points for prequalification, supporting for certification cost and certification sign and mitigation of building standard.

### **4.1.1 Additional Points for Prequalification**

‘Additional points for prequalification’ offers G-SEED certification experienced companies additional points when they participate in a bidding for public project delivery. It could be a factor accelerating certified housing supply since it raises perceived relative profit of supplier. However, it could also be expected that perceived relative profit would not be increased instantly because supplier acquire the points at next project, in other words, supplier cannot have the benefit in short time.

### **4.1.2 Supporting for Certification Cost and Certification Sign**

These policies could raise perceived relative utility of consumer due to the followings. These policies reduce additional costs for G-SEED certification leading to expected profit of supplier increase and then it affects to decrease sales price. Therefore, it is considered that these could raise supply and demand of certified housing simultaneously. Though supporting for certification cost could not be able to increase supply will of supplier since the policy only takes little part of total construction cost that is approximately from 1.1 million won to 1.5 million won. The cost for certification sign(the

sign representing G-SEED certification building) is also not an effective policy to supplier as the same reason.

#### **4.1.3 Mitigation of Building Standard**

It is expected that the policy for mitigating landscaping area could raise certification will of supplier by lowering construction cost. Although, in case of floor space index and height, it could be predicted that supplier's profit is increased due to giving more floor area, feasibility study is needed since mitigated standard creates additional construction cost. However, this policy would able to attract more suppliers if the government gives the reasonable degree of the incentive which is positive to project feasibility of supplier and little effects to environment and landscape of the area.

## **4.2 G-SEED Boosting Policies for Consumer**

On the other hand, there are two policies for consumer. One is 'Reduction of Acquisition' imposed when acquiring and the other is 'Reduction of Property Tax' imposed after acquiring.

### **4.2.1 Reduction of Acquisition and Registration Tax**

Acquisition tax is divided into three types: acquisition tax, local education tax and special tax for rural area. In this research, the tax is regarded 3.16% of sales price since the research only deals new apartment. This could raise purchase demand due to the attraction point of certified apartment because it could bring down whole purchase price of consumer.

### **4.2.2 Reduction of Property Tax**

Property tax would be able to raise purchasing demand by lowering maintenance cost for 5 years because this benefit is applied for 5 years after purchase.

In this way, above policies could be considered as effective factors to increase demand of G-SEED certified housing if consumers know about the details before purchasing. Nevertheless, survey aiming consumer is required since it has effectiveness when the degree of the price attracting consumer is validated.

### **4.3 Summary**

In this chapter, currently valid policies are examined with causal relationship model based on decision-making of participants of G-SEED certified apartment market. As a result, it is figured out that all policies are only focused on short-time perceived utility and profit judged by the price of the certified housing. In this research, it is verified that all policies could not be operated effectively without a thorough examination about appropriacy of the government's supporting money. Other methods such as increasing favorable image of certified housing discussed in chapter 3.3 has to be considered to raise demand and supply simultaneously from a long-term perspective since the government's supporting money has a limitation.



## **Chapter 5. Conclusions**

### **5.1 Results and Discussions**

This research suggests diagram of decision-making relationship of participants of G-SEED certified apartment market using system dynamics method for searching the reason why the number of the certification is not increased consistently in spite of various boosting policies.

#### **5.1.1 Importance of High Market Share**

With the model, it is analyzed that certified housing market is hard to be activated basically for two reasons. The first reason is increased construction cost by additional cost for the certification deprive certification will of supplier and the second reason is raised sales price also deprive purchase will of consumer.

However, it is expected that demand and supply would be increased gradually so long as a market share of the certified housing is increased, that is if market share is increased, favorable image about the certified housing would be formed through word of mouth. Therefore, the policies improving supply will of supplier and favorable image of the certified housing are important.

### **5.1.2 Necessity of Boosting Policies' Propriety Analysis**

When it comes to supplier, although other policies except 'additional points for prequalification' would be effective for raising the rate of the certification by lowering the construction cost and increasing perceived profit, feasibility study is needed to find out appropriacy of supporting cost and mitigation rate. In case of consumer, two policies have positive effects to increase demand by decreasing perceived relative price. However it is also necessary to analyze an accurate degree of supporting amount of money.

## **5.2 Contributions, Limitations and Further Studies**

This research found out that considering ‘both’ stances of housing market’s stakeholder, supplier and consumer, should be considered to make balanced and effective boosting policies. The system dynamics model and results from analysis of current boosting policies could be utilized as a base material for suggesting the direction of housing policy based on market structure. This research only analyzes the effectiveness of currently valid policies, and specific plans for boosting policies would be suggested in further studies.

## References

MOLIT(Ministry of land, infrastructure and transport), “Housing Construction Record Statistics (주택건설실적통계)”  
<<https://stat.molit.go.kr/>> (Mar. 10, 2015)

G-SEED Certification Integrated Operation System, “G-SEED Certification Record“ <<http://www.g-seed.or.kr/>> (Feb. 12, 2015)

PMO(Prime Minister’s Office), Framework Act on Low Carbon, Green Growth (저탄소 녹색성장 기본법) (2013)

MOLIT(Ministry of land, infrastructure and transport), Green Building Supporting Law (녹색건축물 조성지원법) (2013)

MOLIT(Ministry of land, infrastructure and transport), Ministry of Environment, Green Building Certification Standard (녹색건축인증기준) (2013)

Seoul Metropolitan Government, Seoul Green Building Design Standard (서울시 녹색건축물 설계기준) (2013)

USGBC(U.S. Green Building Council), “LEED Certification Record”

<<https://www.usgbc.org/>> (Feb. 12, 2015)

Cho, B. J., Jeon, Y. J. (1998), “Housing Market Structure and Performance”, Report of Housing Research Institute Korea National Housing Corporation, 1 – 60

Cho, S., Lee, S. M. (2007), “Domestic and Foreign Policy and System related to Green Building Construction”, Journal of Korea Green Building Council, 1 – 15

Choi, M. J., Park, M. S., Lee, H. S., Hwang, S. J. (2013), “Dynamic Strategies for Enhancing Apartment Brand Equity in Korean Housing Market”, Journal of Construction Engineering and Management, 14(3), 65 – 77

Cho, D. W. (2013), “G-SEED Certification Trend and Development Direction”, Journal of the Society of Air-Conditioning and Refrigerator Engineers of Korea, 42(9), 18 – 26

Hong, T. H., Jung, K. B., Ji, C. Y. (2014), “Comparison of Environmental Impacts of Green and Traditional Buildings Using Life Cycle Assessment”, Journal of Construction Engineering and Management, 15(3), 58 – 65

Kang, B. R. and Ye, O. K. (2014), “Analysis of the Impact of G-SEED on Real Estate Price –Focused on Apartment House-”, The Geographical Journal

of Korea, 48(1). 79 – 92

KICT(Korea Institute of Civil Engineering and Building Technology)  
(2009), "A Study on Improving Certification Criteria and Boosting Method  
for G-SEED", MOLIT(Ministry of land, infrastructure and transport)

Kim, C. S., Yoon, J. D., Kim, G. S. (2007), "A Study on the Application of  
Incentive to Improve the Green Building Rating System in Multi-family  
Housing", Journal of Architectural Institute of Korea, 23(8), 91 – 98

Kim, J. H., Kang, B. R. (2013), "Analysis of the Impact of G-SEED on Office  
Rent Market", Journal of Korea Real Estate Academy, 55, 61 – 71

Lee, H. J., Nam, K. J., Lee, J. S. (2011), "The Impact of Green Building  
Certification and it's Grade on the Multifamily Housing Price", Journal of  
Urban Design Institute of Korea, 388 – 397

Lee, S. Y., Shin, S. W. (2009), "A Study on the Demand for Green  
Condominium using PSM and UTP Methods", Housing Study Review, 18(1),  
89 – 103

Lee, S. Y. (2009), "The Analysis Green Apartment Sales Price of using PSM  
Method", MS thesis, KunKuk University, Seoul, Korea

Lee, C. H. (2012), “The Effects of Residential Quality of Environment-friendly Apartment on Customer’s Loyalty and Re-purchase Intention: Focused on Resident of Environment-friendly Certified Apartment”, Ph.D thesis, Seoul Venture University, Seoul, Korea

Lee, J. H. (1997), “Housing Economics: Theory and Practice”, Dawoo-Munhwa Press, 10 – 97

Lim, S. J. (2007), “A Case Study of Brand Personality in Apartment : Influence from both Favorable Attitude and Premium Price on Apartment”, MS thesis, Kyung-Hee University, Seoul, Korea

Lee, J. H. (2009), “The Effect of Scarcity Message Type on Consumer Purchase Intension in Sales Promotion”, Ph.D thesis, Sungkyunkwan University, Seoul, Korea

Na, H. J., Park, M. S., Lee, H. S., Whang, S. J. (2011), “Analysis on Liquidity Support Policy of Unsold New Houses through Utilization of CR-REITs—Using System Dynamics—”, Journal of Construction Engineering and Management, 14(5), 12 - 25

Park, S. H. (2009), “A Case Study of the Feasibility Study Project for the LEED Certification”, Journal of Construction Engineering and Management, 97 – 104

Whang, S. J., Park, M. S., Lee, H. S., Yoon, Y. S. (2010), “Analysis of Korean Real Estate Market and Boosting Policies Focusing on Mortgage Loans: Using System Dynamics”, Journal of Construction Engineering and Management, 11(1), 101 – 112

Son, Y. J., Lee, S. H., Kim, J. J. (2010), “Impact of Green Building Rating System on an Apartment Housing Price”, Journal of Korea Institute of Ecological Architecture and Environment, 10(4), 131 – 136

Sung, H. J. (2014), “A Study on the relationship between Apartment Pre-sales Competition Rate and Housing Price Change”, MS thesis, University of Seoul, Seoul, Korea

Shin, S. J. (2014), “A Feasibility Analysis of Incentives for the Green Building Certification Criteria(GBCC) of Apartment Building”, MS thesis, Dong-A University, Busan, Korea

Shin, S. H. (2013), ”Energy·Environment Policy and Industry in Era of Environmental Change“, „City·Environment Leadership Forum, Seoul University, Seoul

Ye, J. S. (2005), “A Study of Scarcity Effect in Marketing”, Ph.D thesis, Korea University, Seoul, Korea



Yeom, S. M. (2004), “UAE Smasung Corporation, Construction Jactpot Signs in Dubai”, KOTRA(Korea Trade-Investment Promotion Agency)

Yoo, Y. K. (2012), “A Study on the Resident’s Awareness for GBCC(Green Building Certification Criteria) in Apartment House”, MS thesis, Chung-Ang University, Seoul, Korea

Ahmad, S., Simomovic, S. P. (2000), “System Dynamics Modeling of Reservoir Operations for Flood Management”, Journal of Computing in Civil Engineering, 14(3), 190 – 191

Ailawadi, K. L., Lehmann, D. R., Neslin, S. A. (2003), “Revenue Premium as an Outcome Measure of Brand Equity”, Journal of Marketing, 67(4), 1 – 17

Berstein, H. M, Russo, M. A. (2014), “Green Multifamily and Single Family Homes: Growth in a Recovering Market”, SmartMarket Report, McGraw Hill Construction, 1 – 64

Brounen, D., Kok, N. (2010), “On the Economics of Energy Labels in the Housing Market”, Institute of Business and Economics Research, Program on Housing and Urban Policy, Working Paper Series No. W10-002, University of California, Berkeley, USA

Elg, F. (2000), “Application of System Dynamics to Brand Management”,

International System Dynamics Conference Presentation, Norway

Wagner, J. and Nobe, M. C. (2011), “LEED Economic Assessment Program(LEAP)”, Proceeding : ICSDC 2011 : Integrating Sustainability Practices in the Construction Industry, 144 – 150

Sauer, M. and Siddiqi, K. (2009), “Incentives for Green Residential Construction”, Construction Research Congress, 578 – 587

Miller, N., Spivey, J., Florance, A. (2008), “Does Green Pay Off”, Journal of Real Estate Portfolio Management, 14(4), 385 – 400

Ruegge, B., Spescha, G., Reutimann, J. (2012), ”Do Investments in Green Building Pay Off?“, Inrate, 1 – 8

Schmitz, A. and Brett, D. L. (2012), “Real Estate Markets Analysis”, HyungSeol Press, 325

## 국 문 초 록

### 녹색건축인증제도 활성화 정책의 실효성 평가

건물부분의 온실가스 감축을 위한 하나의 방법으로 2002 년 정부는 녹색건축인증제도(G-SEED Certification)를 도입하였다. 그러나 정부의 각종 활성화정책에도 불구하고 공동주택부분의 인증건수는 전체 공동주택 사업승인건수의 1% 내외에 불과한 실정이다.

이러한 상황에서 정부의 정책은 대부분 공급자를 대상으로 하고 있으며, 정책개선 방안에 대한 연구도 대부분 공급자를 중심으로 이루어지고 있다. 즉, 시장의 핵심 참여자인 수요자의 역할 및 중요성은 간과되고 있는 실정이다. 하지만 주택시장은 수요자와 공급자의 상호영향을 통해 작동되기 때문에 한쪽에 치우친 시각이 아닌 그들의 포괄적인 관계와 동태성을 고려해야 할 필요가 있다.

따라서 본 연구에서는 녹색건축인증 공동주택시장을 수요자와 공급자의 의사결정을 토대로 분석하여, 통합적인 시스템다이나믹스 연구 모델을 작성한다. 그리고 해당 모델에서 현재 시행중인 정부의 인증 활성화정책이 어떻게 작용하는지 살펴봄으로써 그 실효성을 분석하고자 한다.

이를 통해 향후 녹색건축인증제도의 활성화정책 방향제시를 위한 기초를 마련할 수 있을 것이라 기대할 수 있다.

**주요어:** 녹색건축인증제도, 인센티브, 공동주택, 시스템 다이내믹스

**학 번:** 2014-20508



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**Master of Science in Engineering**

**Validity Evaluation  
of Boosting Policies for G-SEED  
on Housing Market**

**by**

**Jung-Hwa Kim**

Department of Architecture & Architectural Engineering

The Graduate School

Seoul National University

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**A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science in Engineering**

**Seoul National University**

**2016**

## **Abstract**

# **Validity Evaluation of Boosting Policies for G-SEED on Housing Market**

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Since 2002, Korea Government has implemented G-SEED(Green Standard for Energy and Environmental Design) certification for reducing GHG emission in building area. However, total number of G-SEED Certification is only around 1% of total number of approved apartment buildings despite the various boosting policies. In this situation, most boosting policies and policy improvement researches are leaning toward the supplier's aspect. However, comprehensive relation and dynamics between consumer and supplier has to be considered since housing market is operated by market participants' mutual interaction. Therefore, this research presents system



dynamics models based on decision-making analysis of consumer and supplier in G-SEED certified apartment building market. Then, this research evaluates the validity of boosting policies using the model. The proposed analysis can assist government to make next boosting policies for G-SEED certification.

**Keywords: G-SEED, Incentives, Apartment Building, System Dynamics**

**Student Number: 2014-20508**

# Contents

Chapter 1	Introduction .....	1
1.1	Research Background and Objectives .....	1
1.2	Research Scope and Process .....	5
Chapter 2	Preliminary Study .....	7
2.1	G-SEED Certification .....	7
2.2	Boosting Policies and the Effects .....	10
2.3	Demand and Supply Structure of Housing Market.....	12
2.4	System Dynamics .....	14
2.5	Summary .....	16
Chapter 3	Model Development .....	17
3.1	Demand Model of G-SEED Certified Housing .....	19
3.2	Supply Model of G-SEED Certified Housing .....	22
3.3	Demand and Supply Integrated Model of G-SEED Certified Housing .....	26
3.4	Summary .....	31
Chapter 4	Effects Analysis of Boosting Policies .....	32
4.1	G-SEED Boosting Policies for Supplier .....	36
4.2	G-SEED Boosting Policies for Consumer.....	38
4.3	Summary .....	39

Chapter 5	Conclusions.....	40
5.1	Results and Discussions.....	40
5.2	Contributions, Limitations and Further Studies.....	42
Reference.....		43
Abstract (Korean) .....		50

## **List of Tables**

Table 1-1 Biased View of Previous Researches .....	4
Table 2-1 Changes in Boosting Policies for G-SEED Certification.....	11
Table 4-1 Boosting Policies for G-SEED Certification.....	33
Table 4-2 Causal Relationship by Boosting Policies.....	35

## **List of Figures**

Figure 1-1 Trend Comparison between LEED and G-SEED .....	2
Figure 1-2 Research Process .....	6
Figure 2-1 Diagram of System Dynamics.....	14
Figure 3-1 Conceptual Structure of Demand and Supply Model.....	18
Figure 3-2 Decrease in Demand due to Certification Additional Cost..	19
Figure 3-3 Demand Change according to Relative Utility.....	20
Figure 3-4 Increase in Demand due to Favorable Image Formation ...	21
Figure 3-5 Decrease in Supply due to Additional Cost.....	23
Figure 3-6 Increase in Sales Price due to Favorable Image Formation ..	23
Figure 3-7 Property Value Improvement due to Favorable Image Formation .....	25
Figure 3-8 Self-Regulation Effect of Sales Price and Demand and Supply Reference Mode .....	28
Figure 3-9 Demand and Supply Integrated Model of G-SEED Certification Apartment Housing Market .....	29
Figure 4-1 Effects of Boosting Policies for G-SEED Certification .....	32

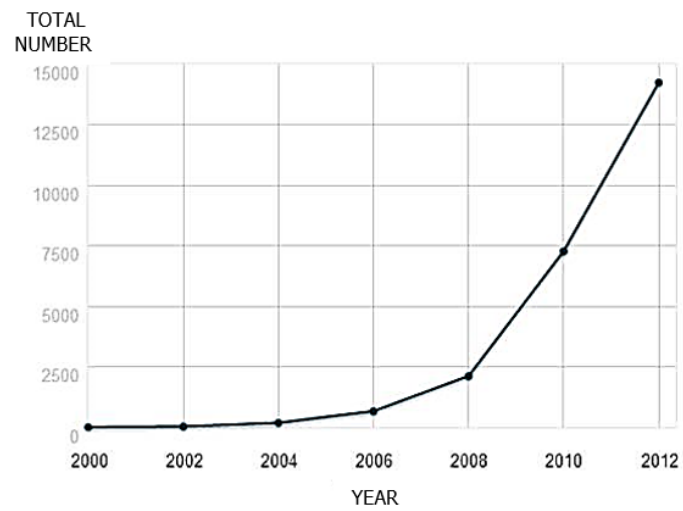
# **Chapter 1. Introduction**

## **1.1 Research Background and Objectives**

As global warming is accelerated, there have been many efforts to reduce GHG gas emission globally. In order to reduce GHG gas emission in construction area, some developed countries such as U.S.A, Germany and Great Britain have introduced green building certification reported to be very effective to GHG gas reduction(Yeom 2013). South Korea also has adopted similar certification called G-SEED (Green Standard for Energy and Environmental Design) from 2002.

LEED (Leadership in Energy and Environment Design), US environmental building certification system has shown continuous annual growth rate over 70% since it has been first implemented in 2000(USGBC 2015). However, even after more than 10 years it has been started and various boosting policies by the government, total certification numbers in apartment building area is still around 1% of total approved apartment building numbers(G-SEED Certification Integrated Operation System 2015). Furthermore, when it comes to the trend pattern it shows that not a continuous increasing pattern as LEED but a repeated rising and falling pattern(Figure 1-1).

## LEED



Brett Molina(2013), USA TODAY

## G-SEED

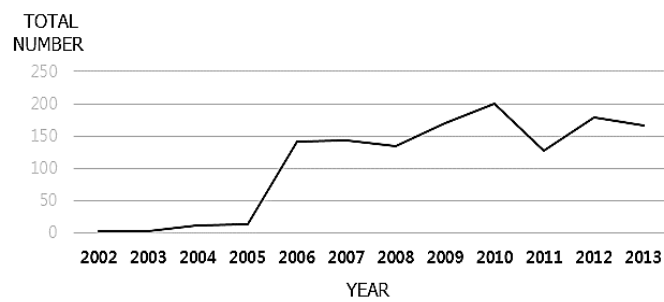


Figure 1-1 Trend Comparison between LEED and G-SEED

Korea Institute of Construction Technology(2009) suggested methods to improve the certification system. These are to make easier acquisition and additional incentives mostly focused on the supplier for boosting G-SEED. Choi(2010) claimed that political support to suppliers is needed emphasizing the importance of their role. Such studies carry an important meaning since it made a counter-offer by analyzing the certification housing market problem. However, they also have limits and these are primarily concentrated in supplier side(Table 1-1). Also, most boosting policies of the government conducted up to now are intended for suppliers.

It is necessary that housing market be analyzed focused on the comprehensive relationship and dynamics rather than the biased viewpoint because the market are operated with participants affecting each other. This research finds out the mutual relationship between consumer and supplier by creating a demand and supply system dynamics model of green building certification apartment which is formed from decision-making of the consumer and the supplier. Thereafter, the elements of green building certification boosting policies of the government are applied on the model. These elements are to be analyzed to find out how the policies make changes to demand and supply, and whether these make number of green building certification increase in the end or not.

The objective of this research is to find out the reasons why G-SEED certification rate is low by presenting decision-making process of certified housing market's participants and analyzing the process using system dynamics method.



Table. 1-1 Biased View of Previous Researches

Researcher	Subject		Contents
	Supplier	Consumer	
Kim et al. 2007	o	x	Analysis of current incentives' application and compare existing one and proposed one. The result from poll is that supplier has been more interested in proposed one and this means current one is not effective.
Korea Institute of Construction Technology 2009	o	x	Propose the following incentives: Mitigation of building standard, reduction of environmental improvement charges and acquisition tax. Suggest improved green building operating system: Establishment of exclusively charged organization for G-SEED etc.
Choi 2010	o	x	Analyze current green policies like G-SEED for improving green building and claim that the political support to suppliers is highly needed due to they are the actual participants of the construction market.
Choi 2010	o	x	Prove that when floor area ratio mitigation incentive is applied, supplier could not get actual profit. Some grade show minus profit. Furthermore, other areas except Seoul have also no profit. Suggest incentive ratio adjustment according to the area.

## **1.2 Research Scope and Process**

This research is limited in apartment building area account for 36% of total energy consumption and is only focused on decision-making process of consumer and supplier even though the market includes many other participants. In fact, there are also important and salient factors affecting supply and demand in housing market which are preferable school districts, region and adjacent to public transportation. However, this research excludes the factors and only focus on the influences of G-SEED certification.

The process for this research is the following:

- (1) Learning about G-SEED certification by literature review
- (2) Finding out how the features of G-SEED certified apartment buildings affect decision-making of consumer and supplier
- (3) Developing the causal relation of the factors that lead to decision-making of consumer and supplier using system dynamics method.
- (4) Validating the effects of boosting policies for G-SEED certification based on the system dynamics model.

The flow diagram of research process is shown in the following Figure 1-2.

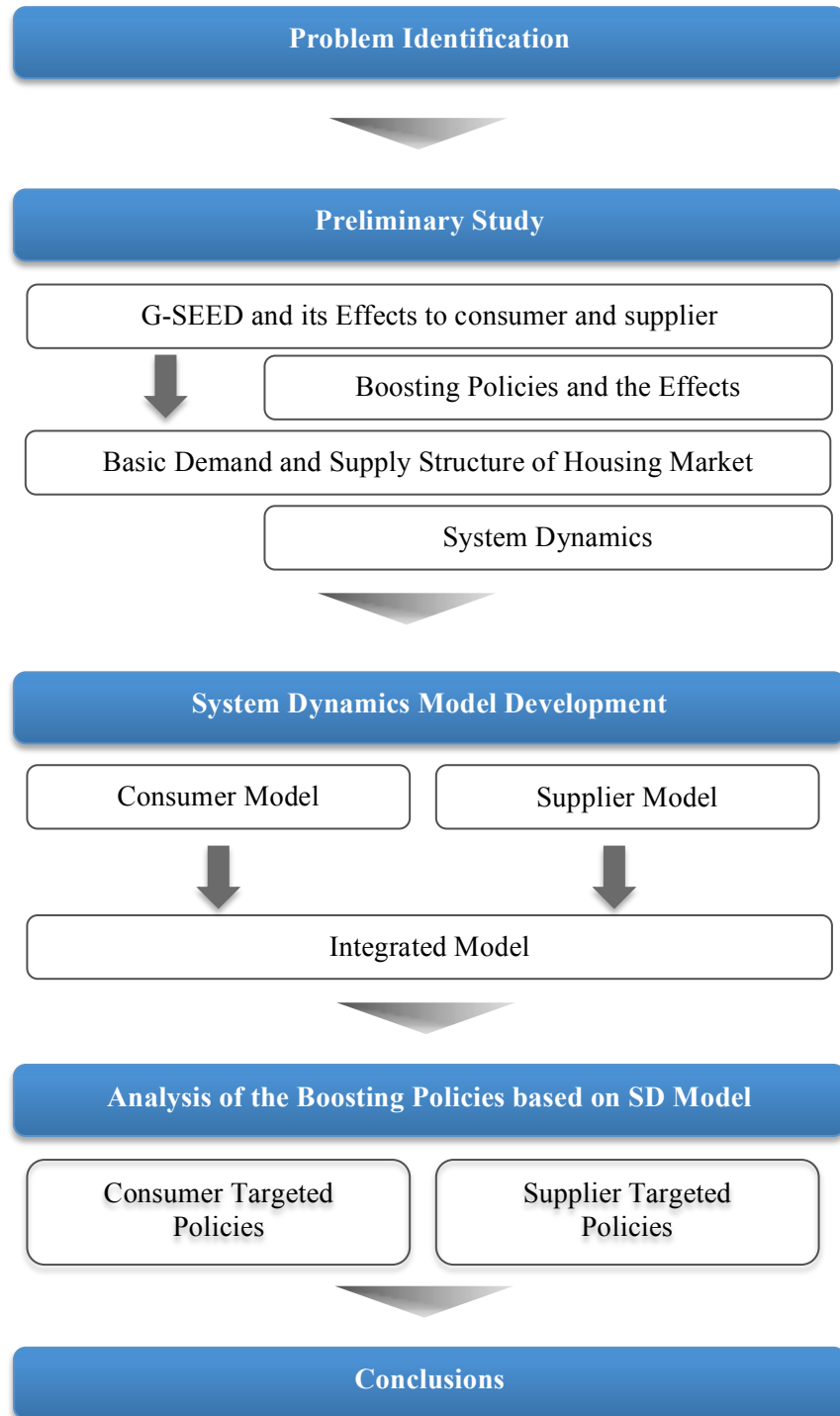


Figure 1-2 Research Process

## **Chapter 2. Preliminary Study**

### **2.1 G-SEED Certification**

G-SEED certification has been implemented to realize sustainable development and induce buildings that are eco-friendly and resource conserved type(Green building improving law, Article 16).

#### **2.1.1 Effects to Consumer**

Living in G-SEED certified buildings results in tenants' health and productivity improvement due to designing nature ventilation and using products emitting low indoor air pollutants such as VOC-zero paint for getting scores of indoor environment part(Cho 2013). Furthermore, tenants could save maintenance costs such as electricity and water bill about 8~9% steadily due to the following factors: Installation of high-efficiency air-conditioning system, water-saving faucet or toilet and waste-water reuse system (Jonathon W. and MaryEllen C. N. 2014). However, increased construction cost for acquiring G-SEED certification makes sales price higher which is a burden on consumer.

Most previous studies about G-SEED certification targeting consumer dealt attractiveness and satisfaction of consumer about certified apartment buildings. Lee and Choi(2012) analyzed that consumers consider G-SEED certified apartment building as a high-quality premium brand because G-

SEED name itself has eco-friendly image. Lee and Shin(2009) also showed the results that consumers recognize certified buildings as better quality buildings and could pay more than the other.

### **2.1.2 Effects to Supplier**

The reason why green building certification is prevalent in developed countries as USA and United Britain is many companies or building owners judge the certification improves their companies' or buildings' image. And these indirect effects could raise their market value(Schmitz A. and Deborah. L B 2012). Actually, many domestic and foreign companies like NAVER and Hearst Corporation adopted green building certification when they build headquarters and utilize it as public relations since they could raise their companies' image as eco-friendly companies. Furthermore, green building certified buildings' value, rate of return on investment and occupancy rate are also increased as 7.5%, 6.6% and 3.5% respectively(Shin 2013). On the other hand, as mentioned above, various additional costs such as construction cost and certification fee are occurred. And these inevitable additional costs act key factors to deprive the certification will of supplier whose goal is maximized profit(Lee et al. 2014).

In this situation, there are many researches to analyze project feasibility and economical feasibility of G-SEED certified apartments. Kang and Yeo(2014) proved that G-SEED certification has positive effects to form apartment price and urge the government to give supports(e.g. various incentives) to boost G-SEED certification. Lee et al.(2011) analyzed the

positive correlation between G-SEED certification and the market price per area. Kim et al.(2007) studied the incentives for G-SEED certified buildings and argued that more supporting policies are required to boost G-SEED certification.

## **2.2 Boosting Policies and the Effects**

The government has introduced various policies from 2006, since the certification rate was too low from 2002 to 2005 when the certification was operated just by market function without intervention of the government. Table 2-1. shows the government's policies for boosting G-SEED certification. Most beneficiary of the policies are biased to supplier and it is mandatory only to public project delivery.

It is found that the certification number was greatly increased from 13 cases to 142 cases as 'Sales Price Cap'(3% of basic construction cost could be added to sales price) has been implemented from 2006. This was figured out from statistics about the annual approved apartment number and G-SEED certified number of it.

Table. 2-1 Changes in Boosting Policies for G-SEED Certification

Year	Related Law	Policy	Target
2006	Rules on Housing Supply (주택공급에 관한 규칙)	Sales Price Cap: 3% addition (분양가 상한제 3% 가산)	Supplier
2007	Additional Cost Standard in Quality Improvement of Apartment (주택품질 향상 에 따른 가산비용 기준)	Sales Price Cap: 1~4% addition (분양가 상한제 1~4% 가산)	Supplier
	Seoul Green Building Standard (서울시 친환경 건축기준)	Additional Points for Prequalification (입찰참가자격 사전심사 가산점)	Supplier
		Supporting for Certification Cost 50~100% (인증비용지원 50~100%)	Supplier
		Supporting for Certification Sign (인증표지지원)	Supplier
		Reduction of Acquisition (취등록세 경감 5~15%)	Consumer
	Daejeon Metropolitan City Guidelines of Built Environment Renewal Development (대전광역시 도시 및 주거환경정비기본계획 운영관리지침)	Mitigation of Building Standard(Floor Space Index) (건축기준 용적률 완화)	Supplier
2011	Green Building Certification Standard (친환경건축물 인증기준)	Mandatory for Architecture more than 10,000 m <sup>2</sup> Gloss Floor Area Implemented by Public Institution (연면적 1 만m <sup>2</sup> 이상 공공기관 시행 건축물 의무)	-
2012	Seoul Green Building Standard (서울시 친환경 건축기준)	Mitigation of Building Standard(Floor Space Index, Height, Landscaping Area) 4~12% (건축기준 용적률, 건축물 높이, 조경면적 완화 4~12%)	Supplier
		Reduction of Property Tax (재산세 경감 3~15%)	Consumer
2013	Green Building Certification Standard (녹색건축물 인증기준)	Mandatory for Architecture more than 10,000 m <sup>2</sup> Gloss Floor Area Implemented by Public Institution (연면적 1 만m <sup>2</sup> 이상 공공기관 시행 건축물 의무)	-



## **2.3 Demand and Supply Structure of Housing Market**

The housing problem could be analyzed with basic concept of demand and supply in common with economical problems(Lee 1997). The consumers pursue utility maximization when they buy housing and the suppliers like housing constructor pursue profit maximization on housing market when they build and supply housing. And housing demand and supply are decided by their decision-making, and housing sales price is determined by time function from these two differences (difference of the demand and supply)(Whang 2010).

Housing demand is set by diverse variables. One of them is the intention of housing purchase: Motivation of residence and purchase(e.g. improvement of housing quality), motivation of asset and investment(e.g. alternative investment income). Another factor is affecting purchase ability: Housing price level and other factor is that influencing ability of loan repayment: Income level. In case of housing supply, there are more simple variables than demand: Housing prices, housing construction costs and available sites that equivalent for the purpose of the supplier, maximization of profit(Lee1997).

If supplier could be survived in today's housing market that has been changed from supplier centered to consumer centered, supplier need to know about future housing demand exactly and predict the change of market structure(Korea National Housing Corporation Housing Lab 1998). Therefore, there are many efforts to develop highly competitive housing products satisfying various requirements of consumer by differentiating image and

brand. Green housing(G-SEED certified housing) which is offered recently for meeting the well-being trend is a representative example.

On the other hand, substitutes refer to the similar products in facility because its purposes are almost same. In housing market, apartment building and single-family homes are substitutes each other due to its purpose is same. With a similar meaning, in apartment housing market, G-SEED certified apartment and non G-SEED certified housing could be called mutual substitutes. When it comes these relationship, if substitutes price is higher, its demand would be decreased which trigger increasing of opponents' demand relatively. In other words, when consumer choose lower priced non G-SEED certified housing, supplier could face difficulties since the unsold-rate of G-SEED certified housing is increased because of dropped G-SEED certified demand.

## 2.4 System Dynamics

System dynamics is one of prevalent modeling methods to suggest analytical solutions for nonlinear phenomena such as social, economic, industrial and environmental problems. This research uses system dynamics because of its effectiveness for analyzing complicated system. The main diagram of system dynamics is as Figure 2-1.



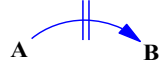
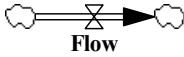



Diagram	Explanation	
	When all other conditions are identical	When Factor A increases (decreases), Factor B increases (decreases)
		When Factor A increases (decreases), Factor B decreases (increases)
	Including weighted delayed time between two factors	
	Flows : Define the rate of change in system states and control quantities flowing into and out of stocks, also called 'Rates'	
	Stocks : Define the state of a system and represent stored quantities, also called 'Levels'	
	Positive feedback or self-reinforcing loop	
	Negative feedback or self-balancing loop	

Figure 2-1. Diagram of System Dynamics (Sterman 2000)

Basically, system dynamics is composed of causality feedback loop and 'Stock-Flow' represents time delay and accumulating process of variables. The causality feedback loop is divided into two loops. The first one is 'Reinforcing loop(R-loop)' makes continuing virtuous or vicious acts and the second one is 'Balancing loop(B-loop)' creates stable situation(Ahmad-Simonovic 2000).

## **2.5 Summary**

This chapter referenced the preliminary study of G-SEED certification and its effects to consumer and supplier respectively. The certification has both pros and cons sides. In case of consumer, various eco-friendly installations for the certification enhance their productivity and reduce maintenance costs. When it comes to supplier, they could improve their images leading to higher profit. Although role of supplier is very important on housing market, the boosting policies skewed towards supplier is considered as a problem since housing market is operated by supplier and consumer together.

System Dynamics has been widely used for complex and complicated problems in various categories. It is also useful to find out variables' relation. With these reasons, the research selected system dynamics method to analyze the housing market and validate the boosting policies.

## Chapter 3. Model Development

This research presents each consumer and supplier causality model and integrated model of them to recognize the relationship between demand and supply and find out the effects of boosting policies. Each consumer and supplier model consists of variables that affect their decision-making when they choose G-SEED certified apartment instead of non-certified one.

Conceptual structure of causality diagram created based on preliminary study is Figure 3-1. Consumer and supplier make decision for their maximized utility and profit respectively. In case of consumers, they would buy G-SEED certified apartment when maintenance cost saving and improvement of living quality(②) is higher than expensive purchase price(①). And supplier would construct and supply G-SEED certified apartment if increased sales rate, price premium and improvement of property value of supplier(④) is higher than increased construction cost(③). In this way, dynamic relation is formed as demand and supply amount that is determined by decision-making of consumer and supplier affects sale price and sales rate and moreover, sales price affects sales rate.

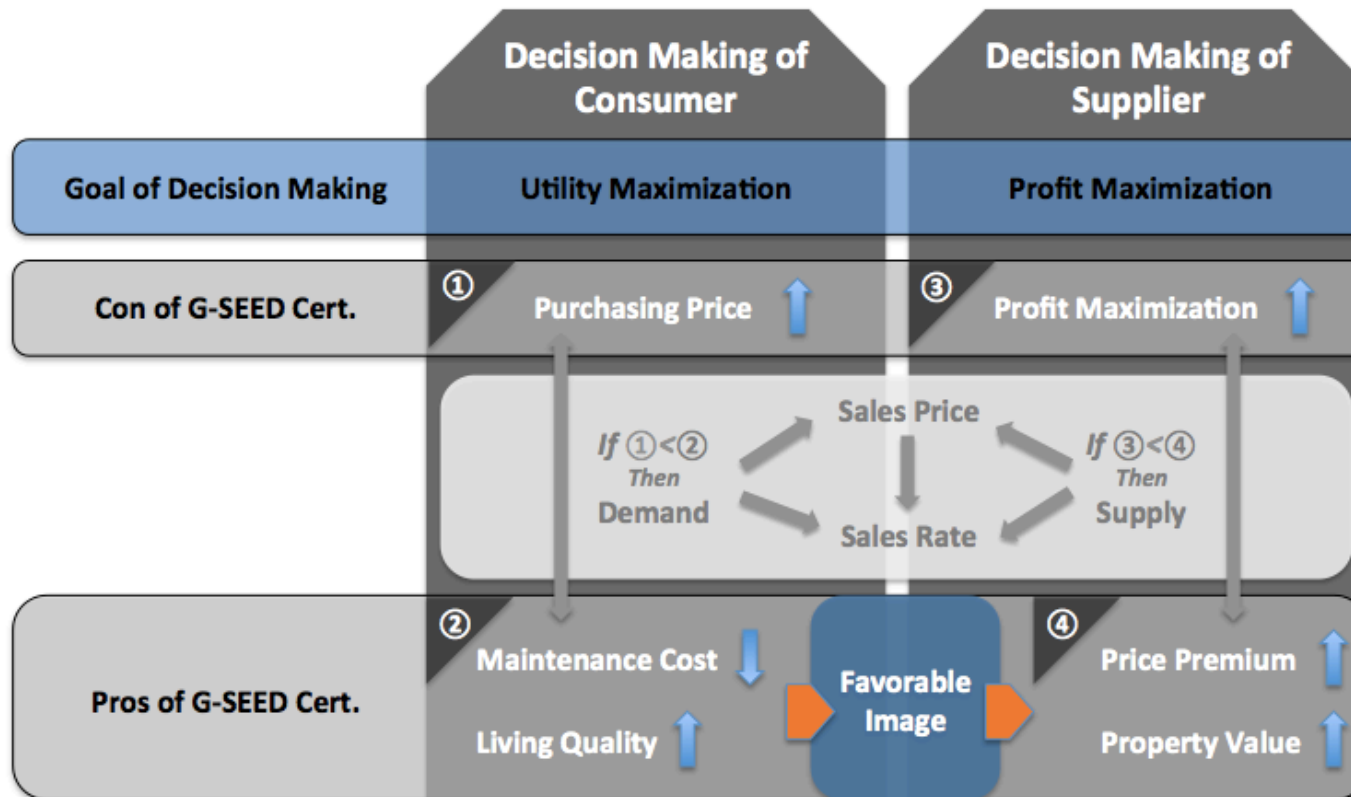


Figure 3-1. Conceptual Structure of Demand and Supply Model

### 3.1 Demand Model of G-SEED Certified Housing

Basically, housing demand could be dealt as a function of ability-to-buy and willing-to-buy. Because housing demand is closely related with pay ability and preference since its concept implies products trading in the market which is same as other products(Lee 1997).

#### 3.1.1 Decrease in Demand due to Certification Additional Cost

Very similar with other goods when housing price is increased, its demand is decreased as well(Whang et al. 2010). Increased ‘Certified Housing Sales Price’ due to ‘Certification Additional Cost’ causes higher ‘Certified Housing Purchase Price’ which results in ‘Certified Housing Demand’ decrease(Figure 3-2).

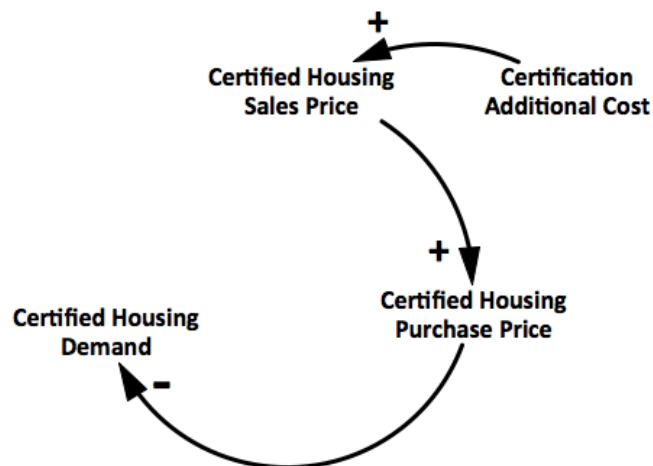


Figure 3-2. Decrease in Demand due to Certification Additional Cost



### 3.1.2 Decrease in Demand due to Certification Additional Cost

Reasonable consumers would buy housing if present value of housing benefit flows(value of housing benefit flows ÷ discount rate) which could be acquired quarterly is perceived more than 'Certified Housing Purchase Price'(Lee 1997). Main benefit of certified housing: maintenance cost could be reduced 8~9% quarterly('Reduction of Cert. Housing Maintenance Cost'). Higher 'Perceived Relative Price' means higher 'Perceived Relative Utility by Consumer' causes 'Certified Housing Demand'(Figure 3-3).

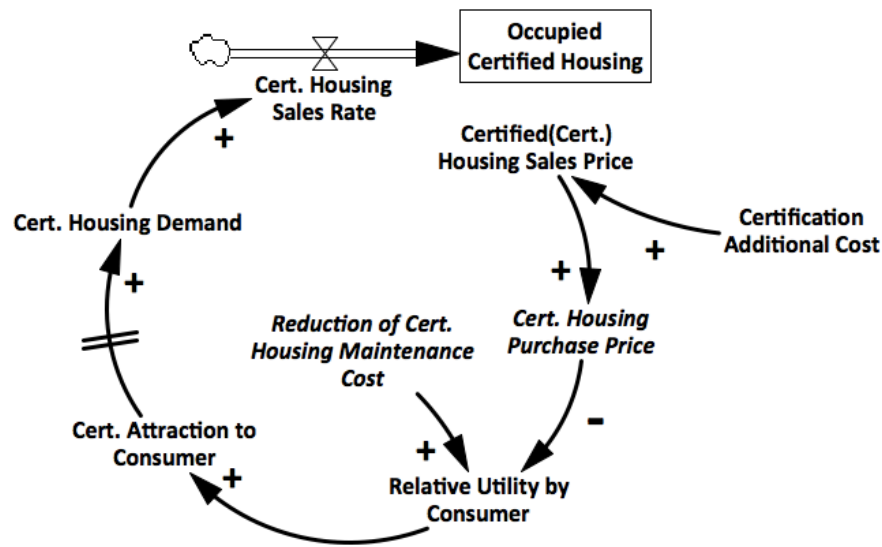


Figure 3-3. Demand Change according to Relative Utility

### 3.1.3 Increase in Demand due to Favorable Image Formation

Consumers make effort to get maximized utility by comparing, analyzing and evaluating many alternatives. The housing quality assessment is difficult before buying and living a house. The risk from uncertainties such as financial, psychological and efficiency called perception risk tend to be relieved by consumer through word of mouth, marketing, brand and price premium of the product at exploration phase(Yoo 2012). High-quality image of certified housing formed from ‘Positive Word of Mouth’, ‘Marketing’ of supplier and ‘Price Premium’ is accumulated as ‘Favorable Image of Certified Housing’. Increased favorable image of certified housing improves ‘Perceived Relative Utility by Consumer’. Subsequently, it creates ‘Certified Housing Demand’ when external factors classified into market condition, related policy and regulatory, geographical condition, area and price are in a best circumstances after some time delay(Choi 2013)(Figure 3-4).

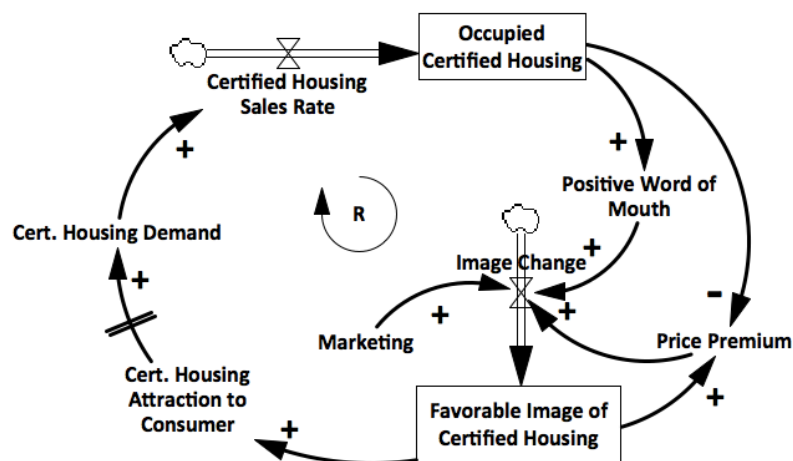


Figure 3-4. Increase in Demand due to Favorable Image Formation

## **3.2 Supply Model of G-SEED Certified Housing**

Housing supply could be divided into new housing and old housing. This research is only concentrated on new housing that is not related to obligations and led by private contractors.

### **3.2.1 Decrease in Supply due to Additional Cost**

As described above, the price of G-SEED certified apartment is higher than non-certified one due to various additional cost(Kim and Kang 2010). Increasing 'Cert. Housing Construction Cost' means decreasing 'Cert. Housing Expected Profit' of supplier that is given when they construct new housing. This makes 'Cert. Housing Supply' lower as dropping 'Cert. Housing Attraction to Supplier' which is compared to non-cert. one. On the other hand, in this research Cert. Housing Supply' is interpreted in the same meaning with the number of the certification because it gives a positive effect on the increase of the certification number. (Figure 3-5).

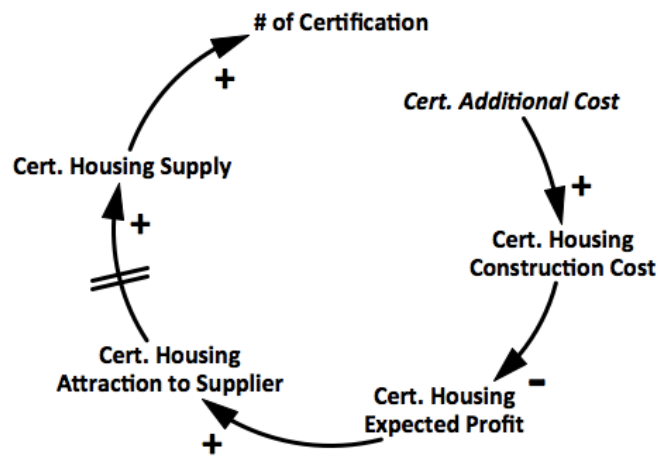


Figure 3-5 Decrease in Supply due to Additional Cost

### 3.2.2 Increase in Sales Price due to Favorable Image Formation

As discussed in chapter 3.1.3, 'Favorable Image of Cert. Housing' makes 'Price Premium' of the Cert. housing and 'Cert. Housing Expected Profit by Supplier' higher. After that it increase 'Cert. Housing Supply' finally (Na et al. 2013) (Figure 3-6).

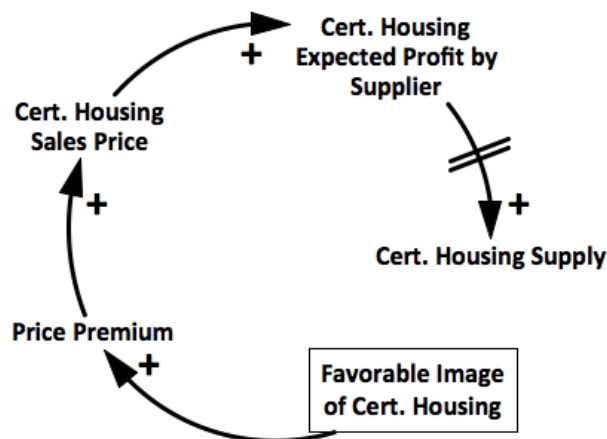


Figure 3-6 Increase in Sales Price due to Favorable Image Formation

### **3.2.3 Property Value Improvement due to Favorable Image**

#### **Formation**

Suppliers could improve their image of companies as eco-friendly companies by supplying G-SEED certified apartments and it means that intangible property value of supplier is increased(Schmitz A. and Deborah. L B 2012). The intangible property value refers to the brand value that has no visible entity but gives substantial value to the company. For instance, the reason why SAMSUNG constructed unprofitable Burj Khalifa in Dubai is the company believed that it improve company's brand value by constructing the tallest building in the world(Yeom 2004). If more certified apartment are supplied, more 'Public Relationship(PR) of Supplier' is increased which lead to 'Favorable Image of Supplier' increasing and then 'Property Value of Supplier' is higher. Property Value affects increasing of supply by hoisting 'Perceived Relative Profit by Supplier' since it is recognized as profit will be appeared in the future(Figure 3-7).

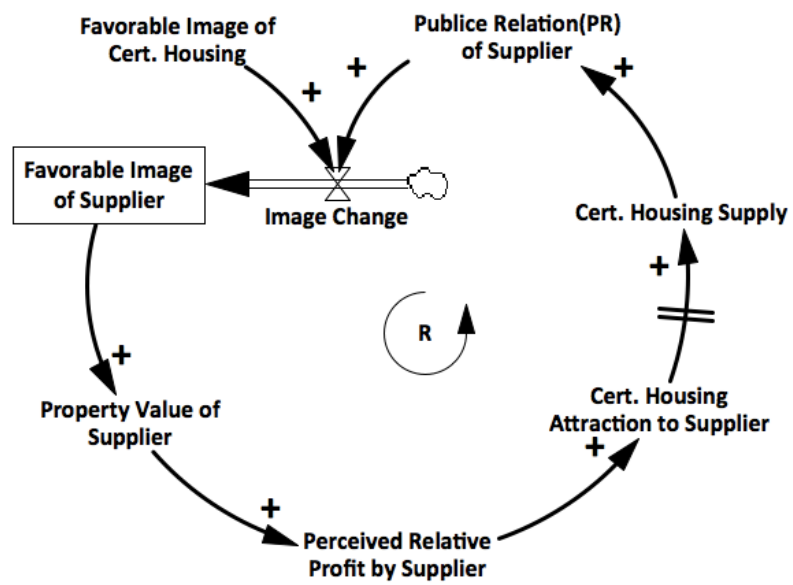


Figure 3-7 Property Value Improvement due to Favorable Image Formation

### **3.3 Demand and Supply Integrated Model of G-SEED**

#### **Certified Housing**

In this chapter, this research finds out integrated and dynamic relationship making demand and supply integrated model Fig. 3-9 based on demand and supply models discussed in chapter 3.1 and 3.2.

#### **3.3.1 Supply, demand and price stability in the market due to the balance**

Increasing of construction cost and purchasing cost due to additional cost for the certification stabilize housing market demoralizing to buy or supply the certified apartments of consumer and supplier. This reaction is determined by the instantaneous without delay(Figure 3-9. Causality relationship from ‘Certification Additional Cost’ to ‘Cert. Housing Demand’ and B-Supply loop).

This could be explained with actual G-SEED certification number transition data. The government expected that the certification market could be activated just by market function without the government’s intervention from 2002(starting point) to 2005. However, certification number in this period is only 2~13(Figure 3-8. Actual Data).

It is possible to infer that expected profit would be decreased because additional cost lower ‘Perceived Relative Profit by Supplier’(Figure 3-9 Causality relationship from ‘Certification Additional Cost’ to ‘Perceived

Relative Profit by Supplier’). However, when sales price could be set higher than market price as implementation of ‘Sales Price Cap’ in 2006, the number of the certification has risen greatly over 10 multiples(Figure 3-8. Actual Data).

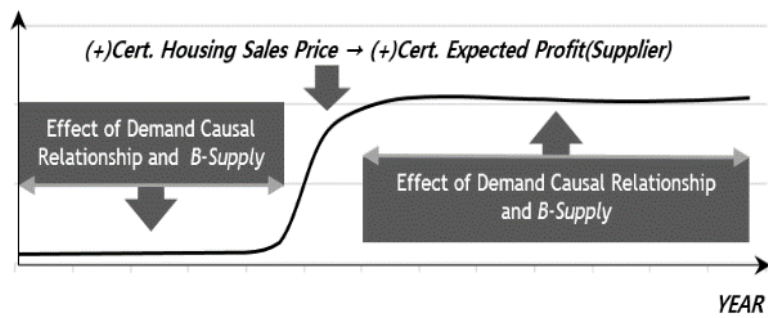
High sales price influences expected profit of supplier and perceived relative profit increasing which result in certified housing supply rise. On the other hand, high sales price causes purchase price increasing and demand decreasing which result in unsold state. It is expected that B-Supply loop is activated due to lowering expected profit of supplier finally(Figure 3-9).

Figure 3-8 represents causality relationship of consumer part (From ‘Certification Additional Cost’ to ‘Cert. Housing Demand’), reference mode of B-Supply loop effect and actual data, which are very similar to trend. Although supply is restrained by early price, when policies are implemented supply is increased due to rise of suppliers’ expected sales price. However, it could be found the market is stabilized again since B-Supply loop would be activated by increased sales price and decreased demand.



### Reference Mode

# NUMBER of G-SEED Certification



### Actual Data

# NUMBER of G-SEED Certification

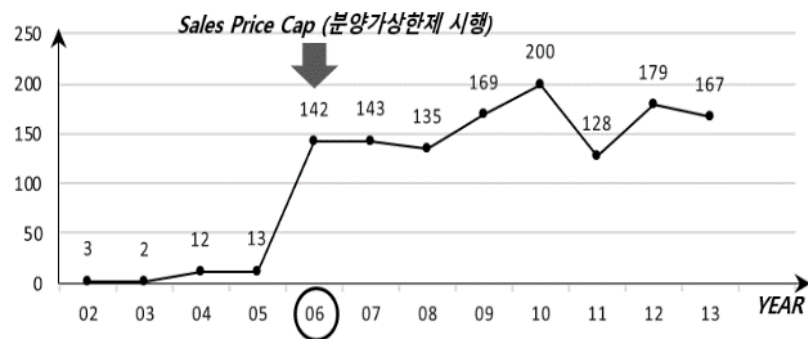


Figure 3-8 Self-Relation Effect of Sales Price  
and Demand-Supply Reference Mode

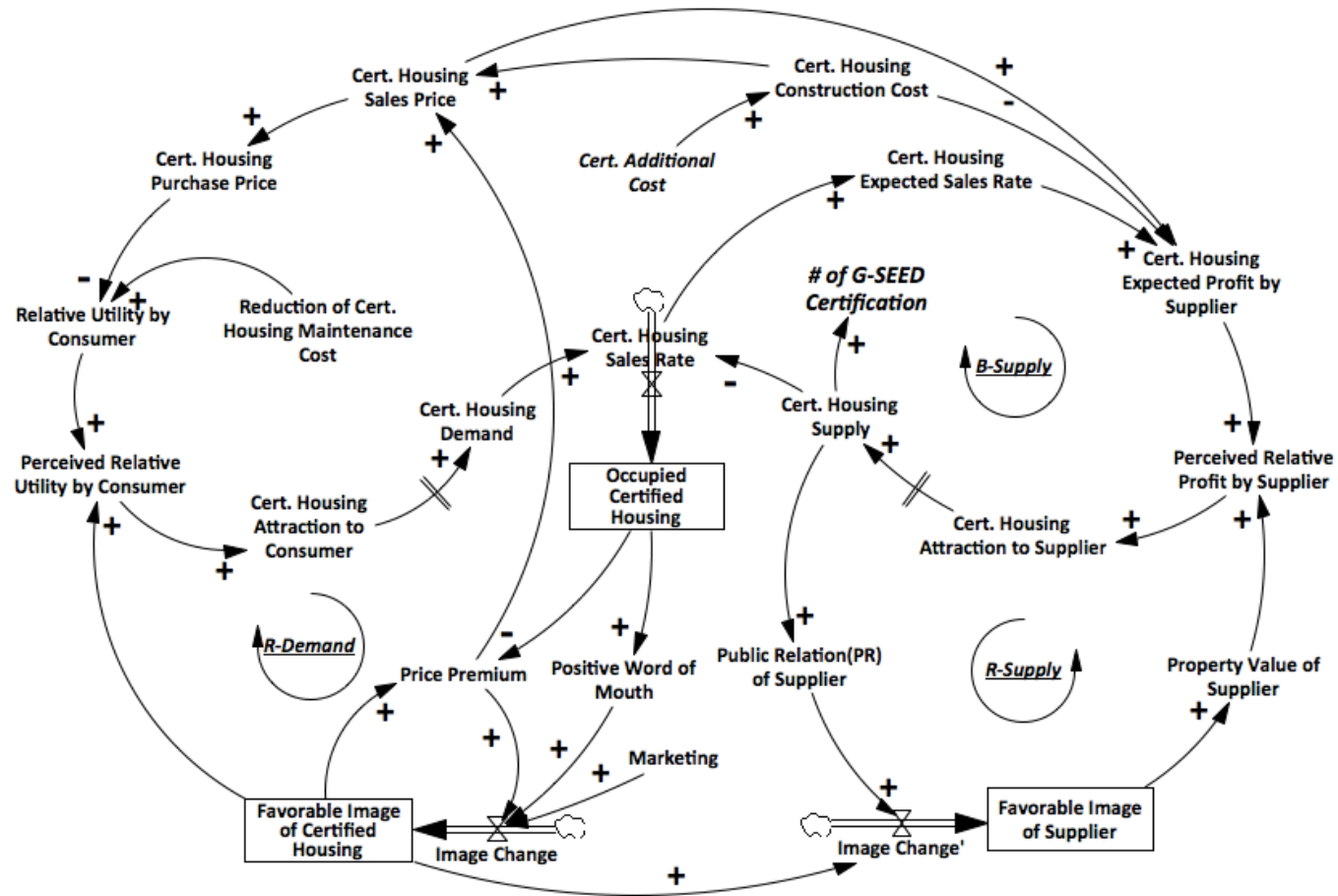


Figure 3-9 Demand and Supply integrated Model of G-SEED Certification Apartment Housing Market

### **3.3.2 Activation of the Market through Favorable Image**

#### **Formation**

However, demand could be increased by the following sequential process. Favorable image formation from positive word of mouth and marketing make price premium which raise favorable image again and this lower the concern about the risk that consumer could have when they buy apartment. Although short-term effect could not be possible since accumulated certified housing demand that affects word of mouth premises occupied certified housing and a considerable time delay is entailed from favorable image formation to certified housing demand. Furthermore, it takes substantial time for making favorable image of supplier by certified housing supply and increasing of property value of supplier. Therefore, it is expected that short-time effect from the causality is not easy.

### **3.4 Summary**

This research suggests that demand for certified apartment is decided by additional cost, relative utility and favorable image of it. When it comes to supply, key determination factors are increased construction cost, favorable image and good possibility to improve asset value. Short-term or promptly perceived effects tend to lower demand and supply. On the other hand, long-term effect from favorable image makes the housing market actively. In this sense, making favorable image of the certified housing is urgent to increase the number of G-SEED certification.

## Chapter 4. Effects Analysis of Boosting Policies

In this chapter, the research discusses G-SEED boosting policies' effectiveness by finding out the influential relationship of the policies assigned to the integrated system dynamics model that is developed in chapter 3. The government has been implemented various policies to boost G-SEED certification and still valid policies are described in Table 4-1. Figure 4-1 express influence of policies in demand and supply integrated model of Figure 3-9 and Table 4-2 shows the causal relationship with policies.

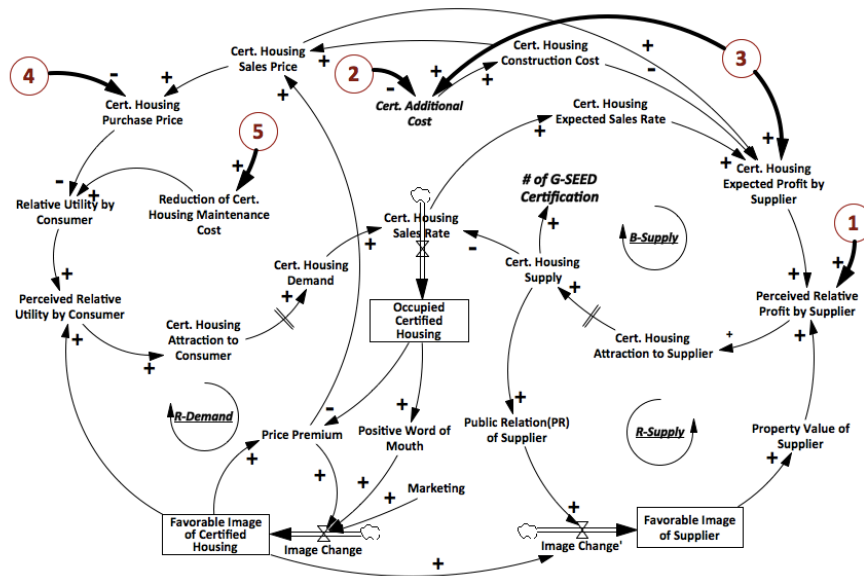


Figure 4-1 Effects of Boosting Policies for G-SEED Certification

Table 4-1 Boosting Policies for G-SEED Certification

Target		Contents	Detail		Source
Supplier	①	<b>Additional Points for Prequalification</b>	•Grant to constructor or designer having G-SEED certification experience		•Seoul Green Building Standard
	②	<b>Supporting for Certification Cost 50~100%</b>	<b>Number of Unit</b>	<b>Maximum Supporting Cost</b>	•Green Building Certification Standard
			Less than 500Units	11,280,000 Won	
			Less than 500~1500Units	13,170,000 Won	
			More than 1500Units	15,590,000 Won	
			<b>Certification Grade</b>	<b>Supporting Ratio</b>	•Seoul Green Building Standard
			Green 1 <sup>st</sup> Grade	100%	
			Green 2 <sup>nd</sup> Grade	80%	
			Green 3 <sup>rd</sup> Grade	70%	
			Green 4 <sup>th</sup> Grade	50%	
		<b>Supporting for Certification Sign</b>	-		
	③	<b>Mitigation of Building Standard(Floor Space Index, Height, Landscaping Area) 4~12%</b>	<b>Energy Standard</b>	<b>G-SEED Certification</b>	
				<b>Green 1<sup>st</sup> Grade</b>	<b>Green 2<sup>nd</sup> Grade</b>
			Energy Efficiency 1 <sup>st</sup> Grade	12%	8%
			Energy Efficiency 2 <sup>nd</sup> Grade	8%	4%
					•Green Building Supporting Law •Seoul Green Building Standard

Target		Contents	Detail				Source	
Consumer	④	Reduction of Acquisition and Registration Tax 5~15%	•Acquisition Tax: One should pay 3.16% of sales price when purchasing new apartment				•Local Tax Law	
			Type	Acquisition Tax	Local Education Tax	Special Tax for Rural area		
			Ratio	2.8%	0.2%	0.2%		
			Energy Standard		G-SEED Certification		•Restriction of Special Taxation Act •Seoul Green Building Standard	
					Green 1 <sup>st</sup> Grade	Green 2 <sup>nd</sup> Grade		
			EPI more than 90points or Energy Efficiency 1 <sup>st</sup> Grade		15%	10%		
			EPI more than 80points & less than 90points or Energy Efficiency 2 <sup>nd</sup> Grade		10%	3%		
	⑤	Reduction of Property Tax 3~15%	•Effective Period : For 5 years after purchase				•Restriction of Special Taxation Act •Seoul Green Building Standard	
			Energy Standard		G-SEED Certification			
					Green 1 <sup>st</sup> Grade	Green 2 <sup>nd</sup> Grade		None Grade
Energy Efficiency 1 <sup>st</sup> Grade			15%	10%	3%			
Energy Efficiency 2 <sup>nd</sup> Grade			10%	3%	-			
None Grade		3%	-	-				

Table 4-2 Causal Relationship by Boosting Policies

Policy		Causal Relationship
①	<b>Additional Points for Prequalification</b>	①→ (+)Perceived Relative Profit by Supplier → (+)Cert. Housing Attraction to Supplier→ (+)Cert. Housing Supply→ (+)# of G-SEED Certification
②	<b>Supporting for Certification Cost and Sign</b>	②→ (-)Cert. Additional Cost→ (+)Cert. Housing Construction Cost→ (+)Cert. Expected Profit by Supplier→ ...→ (+)# of G-SEED Certification
③	<b>Mitigation of Building Standard</b>	③→ (+)Cert. Additional Cost→ (+)Cert. Housing Construction Cost ↓ (-) ③→ (+)Cert. Expected Profit by Supplier→ ...→ (+)# of G-SEED Certification
④	<b>Reduction of Acquisition Tax</b>	④→ (-)Cert. Housing Purchase Price→ (+)Relative Utility by Consumer→ (+)Perceived Relative Utility by Consumer→ (+)Cert. Housing Attraction to Consumer→ (+)Cert. Housing Demand→ (+)Cert. Housing Sales Rate→ (+)Cert. Housing Expected Sales Rate→ ...→ (+)# of G-SEED Certification
⑤	<b>Reduction of Property Tax</b>	⑤→ (+)Reduction of Cert. Housing Maintenance Cost→ (+)Relative Utility by Consumer→ (+)Perceived Relative Utility by Consumer→ ...→ (+)Cert. Housing Demand→ ...→ (+)# of G-SEED Certification



## **4.1 G-SEED Boosting Policies for Supplier**

There are three types of policies for supplier: additional points for prequalification, supporting for certification cost and certification sign and mitigation of building standard.

### **4.1.1 Additional Points for Prequalification**

‘Additional points for prequalification’ offers G-SEED certification experienced companies additional points when they participate in a bidding for public project delivery. It could be a factor accelerating certified housing supply since it raises perceived relative profit of supplier. However, it could also be expected that perceived relative profit would not be increased instantly because supplier acquire the points at next project, in other words, supplier cannot have the benefit in short time.

### **4.1.2 Supporting for Certification Cost and Certification Sign**

These policies could raise perceived relative utility of consumer due to the followings. These policies reduce additional costs for G-SEED certification leading to expected profit of supplier increase and then it affects to decrease sales price. Therefore, it is considered that these could raise supply and demand of certified housing simultaneously. Though supporting for certification cost could not be able to increase supply will of supplier since the policy only takes little part of total construction cost that is approximately from 1.1 million won to 1.5 million won. The cost for certification sign(the

sign representing G-SEED certification building) is also not an effective policy to supplier as the same reason.

#### **4.1.3 Mitigation of Building Standard**

It is expected that the policy for mitigating landscaping area could raise certification will of supplier by lowering construction cost. Although, in case of floor space index and height, it could be predicted that supplier's profit is increased due to giving more floor area, feasibility study is needed since mitigated standard creates additional construction cost. However, this policy would able to attract more suppliers if the government gives the reasonable degree of the incentive which is positive to project feasibility of supplier and little effects to environment and landscape of the area.

## **4.2 G-SEED Boosting Policies for Consumer**

On the other hand, there are two policies for consumer. One is 'Reduction of Acquisition' imposed when acquiring and the other is 'Reduction of Property Tax' imposed after acquiring.

### **4.2.1 Reduction of Acquisition and Registration Tax**

Acquisition tax is divided into three types: acquisition tax, local education tax and special tax for rural area. In this research, the tax is regarded 3.16% of sales price since the research only deals new apartment. This could raise purchase demand due to the attraction point of certified apartment because it could bring down whole purchase price of consumer.

### **4.2.2 Reduction of Property Tax**

Property tax would be able to raise purchasing demand by lowering maintenance cost for 5 years because this benefit is applied for 5 years after purchase.

In this way, above policies could be considered as effective factors to increase demand of G-SEED certified housing if consumers know about the details before purchasing. Nevertheless, survey aiming consumer is required since it has effectiveness when the degree of the price attracting consumer is validated.

### **4.3 Summary**

In this chapter, currently valid policies are examined with causal relationship model based on decision-making of participants of G-SEED certified apartment market. As a result, it is figured out that all policies are only focused on short-time perceived utility and profit judged by the price of the certified housing. In this research, it is verified that all policies could not be operated effectively without a thorough examination about appropriacy of the government's supporting money. Other methods such as increasing favorable image of certified housing discussed in chapter 3.3 has to be considered to raise demand and supply simultaneously from a long-term perspective since the government's supporting money has a limitation.

## **Chapter 5. Conclusions**

### **5.1 Results and Discussions**

This research suggests diagram of decision-making relationship of participants of G-SEED certified apartment market using system dynamics method for searching the reason why the number of the certification is not increased consistently in spite of various boosting policies.

#### **5.1.1 Importance of High Market Share**

With the model, it is analyzed that certified housing market is hard to be activated basically for two reasons. The first reason is increased construction cost by additional cost for the certification deprive certification will of supplier and the second reason is raised sales price also deprive purchase will of consumer.

However, it is expected that demand and supply would be increased gradually so long as a market share of the certified housing is increased, that is if market share is increased, favorable image about the certified housing would be formed through word of mouth. Therefore, the policies improving supply will of supplier and favorable image of the certified housing are important.

### **5.1.2 Necessity of Boosting Policies' Propriety Analysis**

When it comes to supplier, although other policies except 'additional points for prequalification' would be effective for raising the rate of the certification by lowering the construction cost and increasing perceived profit, feasibility study is needed to find out appropriacy of supporting cost and mitigation rate. In case of consumer, two policies have positive effects to increase demand by decreasing perceived relative price. However it is also necessary to analyze an accurate degree of supporting amount of money.

## **5.2 Contributions, Limitations and Further Studies**

This research found out that considering ‘both’ stances of housing market’s stakeholder, supplier and consumer, should be considered to make balanced and effective boosting policies. The system dynamics model and results from analysis of current boosting policies could be utilized as a base material for suggesting the direction of housing policy based on market structure. This research only analyzes the effectiveness of currently valid policies, and specific plans for boosting policies would be suggested in further studies.

## References

MOLIT(Ministry of land, infrastructure and transport), “Housing Construction Record Statistics (주택건설실적통계)”  
<<https://stat.molit.go.kr/>> (Mar. 10, 2015)

G-SEED Certification Integrated Operation System, “G-SEED Certification Record“ <<http://www.g-seed.or.kr/>> (Feb. 12, 2015)

PMO(Prime Minister’s Office), Framework Act on Low Carbon, Green Growth (저탄소 녹색성장 기본법) (2013)

MOLIT(Ministry of land, infrastructure and transport), Green Building Supporting Law (녹색건축물 조성지원법) (2013)

MOLIT(Ministry of land, infrastructure and transport), Ministry of Environment, Green Building Certification Standard (녹색건축인증기준) (2013)

Seoul Metropolitan Government, Seoul Green Building Design Standard (서울시 녹색건축물 설계기준) (2013)

USGBC(U.S. Green Building Council), “LEED Certification Record”



<<https://www.usgbc.org/>> (Feb. 12, 2015)

Cho, B. J., Jeon, Y. J. (1998), “Housing Market Structure and Performance”, Report of Housing Research Institute Korea National Housing Corporation, 1 – 60

Cho, S., Lee, S. M. (2007), “Domestic and Foreign Policy and System related to Green Building Construction”, Journal of Korea Green Building Council, 1 – 15

Choi, M. J., Park, M. S., Lee, H. S., Hwang, S. J. (2013), “Dynamic Strategies for Enhancing Apartment Brand Equity in Korean Housing Market”, Journal of Construction Engineering and Management, 14(3), 65 – 77

Cho, D. W. (2013), “G-SEED Certification Trend and Development Direction”, Journal of the Society of Air-Conditioning and Refrigerator Engineers of Korea, 42(9), 18 – 26

Hong, T. H., Jung, K. B., Ji, C. Y. (2014), “Comparison of Environmental Impacts of Green and Traditional Buildings Using Life Cycle Assessment”, Journal of Construction Engineering and Management, 15(3), 58 – 65

Kang, B. R. and Ye, O. K. (2014), “Analysis of the Impact of G-SEED on Real Estate Price –Focused on Apartment House-”, The Geographical Journal

of Korea, 48(1). 79 – 92

KICT(Korea Institute of Civil Engineering and Building Technology)  
(2009), "A Study on Improving Certification Criteria and Boosting Method  
for G-SEED", MOLIT(Ministry of land, infrastructure and transport)

Kim, C. S., Yoon, J. D., Kim, G. S. (2007), "A Study on the Application of  
Incentive to Improve the Green Building Rating System in Multi-family  
Housing", Journal of Architectural Institute of Korea, 23(8), 91 – 98

Kim, J. H., Kang, B. R. (2013), "Analysis of the Impact of G-SEED on Office  
Rent Market", Journal of Korea Real Estate Academy, 55, 61 – 71

Lee, H. J., Nam, K. J., Lee, J. S. (2011), "The Impact of Green Building  
Certification and it's Grade on the Multifamily Housing Price", Journal of  
Urban Design Institute of Korea, 388 – 397

Lee, S. Y., Shin, S. W. (2009), "A Study on the Demand for Green  
Condominium using PSM and UTP Methods", Housing Study Review, 18(1),  
89 – 103

Lee, S. Y. (2009), "The Analysis Green Apartment Sales Price of using PSM  
Method", MS thesis, KunKuk University, Seoul, Korea

Lee, C. H. (2012), “The Effects of Residential Quality of Environment-friendly Apartment on Customer’s Loyalty and Re-purchase Intention: Focused on Resident of Environment-friendly Certified Apartment”, Ph.D thesis, Seoul Venture University, Seoul, Korea

Lee, J. H. (1997), “Housing Economics: Theory and Practice”, Dawoo-Munhwa Press, 10 – 97

Lim, S. J. (2007), “A Case Study of Brand Personality in Apartment : Influence from both Favorable Attitude and Premium Price on Apartment”, MS thesis, Kyung-Hee University, Seoul, Korea

Lee, J. H. (2009), “The Effect of Scarcity Message Type on Consumer Purchase Intension in Sales Promotion”, Ph.D thesis, Sungkyunkwan University, Seoul, Korea

Na, H. J., Park, M. S., Lee, H. S., Whang, S. J. (2011), “Analysis on Liquidity Support Policy of Unsold New Houses through Utilization of CR-REITs—Using System Dynamics—”, Journal of Construction Engineering and Management, 14(5), 12 - 25

Park, S. H. (2009), “A Case Study of the Feasibility Study Project for the LEED Certification”, Journal of Construction Engineering and Management, 97 – 104

Whang, S. J., Park, M. S., Lee, H. S., Yoon, Y. S. (2010), “Analysis of Korean Real Estate Market and Boosting Policies Focusing on Mortgage Loans: Using System Dynamics”, Journal of Construction Engineering and Management, 11(1), 101 – 112

Son, Y. J., Lee, S. H., Kim, J. J. (2010), “Impact of Green Building Rating System on an Apartment Housing Price”, Journal of Korea Institute of Ecological Architecture and Environment, 10(4), 131 – 136

Sung, H. J. (2014), “A Study on the relationship between Apartment Pre-sales Competition Rate and Housing Price Change”, MS thesis, University of Seoul, Seoul, Korea

Shin, S. J. (2014), “A Feasibility Analysis of Incentives for the Green Building Certification Criteria(GBCC) of Apartment Building”, MS thesis, Dong-A University, Busan, Korea

Shin, S. H. (2013), ”Energy·Environment Policy and Industry in Era of Environmental Change“, „City·Environment Leadership Forum, Seoul University, Seoul

Ye, J. S. (2005), “A Study of Scarcity Effect in Marketing”, Ph.D thesis, Korea University, Seoul, Korea

Yeom, S. M. (2004), “UAE Smasung Corporation, Construction Jactpot Signs in Dubai”, KOTRA(Korea Trade-Investment Promotion Agency)

Yoo, Y. K. (2012), “A Study on the Resident’s Awareness for GBCC(Green Building Certification Criteria) in Apartment House”, MS thesis, Chung-Ang University, Seoul, Korea

Ahmad, S., Simomovic, S. P. (2000), “System Dynamics Modeling of Reservoir Operations for Flood Management”, Journal of Computing in Civil Engineering, 14(3), 190 – 191

Ailawadi, K. L., Lehmann, D. R., Neslin, S. A. (2003), “Revenue Premium as an Outcome Measure of Brand Equity”, Journal of Marketing, 67(4), 1 – 17

Berstein, H. M, Russo, M. A. (2014), “Green Multifamily and Single Family Homes: Growth in a Recovering Market”, SmartMarket Report, McGraw Hill Construction, 1 – 64

Brounen, D., Kok, N. (2010), “On the Economics of Energy Labels in the Housing Market”, Institute of Business and Economics Research, Program on Housing and Urban Policy, Working Paper Series No. W10-002, University of California, Berkeley, USA

Elg, F. (2000), “Application of System Dynamics to Brand Management”,

International System Dynamics Conference Presentation, Norway

Wagner, J. and Nobe, M. C. (2011), “LEED Economic Assessment Program(LEAP)”, Proceeding : ICSDC 2011 : Integrating Sustainability Practices in the Construction Industry, 144 – 150

Sauer, M. and Siddiqi, K. (2009), “Incentives for Green Residential Construction”, Construction Research Congress, 578 – 587

Miller, N., Spivey, J., Florance, A. (2008), “Does Green Pay Off”, Journal of Real Estate Portfolio Management, 14(4), 385 – 400

Ruegge, B., Spescha, G., Reutimann, J. (2012), ”Do Investments in Green Building Pay Off?“, Inrate, 1 – 8

Schmitz, A. and Brett, D. L. (2012), “Real Estate Markets Analysis”, HyungSeol Press, 325

## 국 문 초 록

### 녹색건축인증제도 활성화 정책의 실효성 평가

건물부분의 온실가스 감축을 위한 하나의 방법으로 2002 년 정부는 녹색건축인증제도(G-SEED Certification)를 도입하였다. 그러나 정부의 각종 활성화정책에도 불구하고 공동주택부분의 인증건수는 전체 공동주택 사업승인건수의 1% 내외에 불과한 실정이다.

이러한 상황에서 정부의 정책은 대부분 공급자를 대상으로 하고 있으며, 정책개선 방안에 대한 연구도 대부분 공급자를 중심으로 이루어지고 있다. 즉, 시장의 핵심 참여자인 수요자의 역할 및 중요성은 간과되고 있는 실정이다. 하지만 주택시장은 수요자와 공급자의 상호영향을 통해 작동되기 때문에 한쪽에 치우친 시각이 아닌 그들의 포괄적인 관계와 동태성을 고려해야 할 필요가 있다.

따라서 본 연구에서는 녹색건축인증 공동주택시장을 수요자와 공급자의 의사결정을 토대로 분석하여, 통합적인 시스템다이나믹스 연구 모델을 작성한다. 그리고 해당 모델에서 현재 시행중인 정부의 인증 활성화정책이 어떻게 작용하는지 살펴봄으로써 그 실효성을 분석하고자 한다.

이를 통해 향후 녹색건축인증제도의 활성화정책 방향제시를 위한 기초를 마련할 수 있을 것이라 기대할 수 있다.

**주요어:** 녹색건축인증제도, 인센티브, 공동주택, 시스템 다이내믹스

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