Reitaku Institute of Political Economics and Social Studies

Working Report, No.40

Will green buildings be appropriately valued by the market?

Chihiro Shimizu

July 1.2010

Reitaku Institute of Political Economics and Social Studies
Reitaku University

Will green buildings be appropriately valued by the market?[1)]

Chihiro Shimizu[2)]

July 1. 2010

Abstract

As interest grows in environmentally friendly buildings, or “green buildings,” the real estate industry is expected to play an increasingly active role in the realization of a low-carbon society. Various efforts toward such society are now being promoted vigorously within an international framework.
To supply a socially desirable level of green building via the market mechanism, the economic value of green buildings (as measured by the marketplace) must be commensurate with the required investment. Many remain skeptical, however, about the true economic value of green buildings. A thorough analysis has yet to be conducted to evaluate whether green buildings realize income increases commensurate with the enormous initial investments required, although it is clear that cost savings do result from lower energy consumption. The issue becomes even more complex when we consider whether net income increases over short and medium-to-long investment periods, given that future repair costs are proportional to the initial investment. Another question is how these buildings will be valued in the market once they are offered for sale.
This paper shows, through a series of analyses, that in order for green buildings to produce economic value, accurate information about the buildings must be disseminated throughout the marketplace, market participants’ behavior must be transformed by such information, and public regulations must be in place to effect this behavioral transformation. Based on a demonstration analysis of the housing market, the author shows that new condominiums with “green” labels command a premium of approximately 5 percent. Through these analyses, the author suggests that in the real estate investment market, the longer the investment period, the more important it is to plan for environmental risks.

JEL Classification Number: Q38, Q51, Q56, R21, R31

Keywords: green building, corporate real estate strategy (CRE), corporate social responsibility (CSR), sustainability, environmental information code

[1]) This paper was written as an application to the real estate investment market of issues discussed in Yoshida, J. and Shimizu, C. (2010), “Impact of Green Buildings on the Real Estate Price: A Case of New Condominiums Market in Japan,” *CSIS (University of Tokyo) Discussion Paper*, No. 106.
[2]) Associate Professor at The International School of Economics and Business Administration, Reitaku University.(PhD).

1. Introduction: What is a green building?

As scientists elucidate in increasing detail the mechanism of global warming, or how carbon compounds produced from economic activities produce climate change, global warming has become recognized not just as an economic issue, but also as a comprehensive global issue vital to ecological protection. Accordingly, the realization of a low-carbon society has become one of today's highest international priorities.

Some are still skeptical of the causal linkage between carbon compounds and global warming. It is unimaginable, however, that efforts toward the realization of a low-carbon society will be reduced because of these doubts; rather, it seems that if anything they will increase.[3)]

How, then, will the real estate market be affected as environmental policy progresses? And what economic value will be produced by the environmentally friendly buildings, or green buildings, which these environmental efforts have given birth to? Takagi and Shimizu (2009) pointed out that the impact of environmental considerations can be assessed in terms of "investment activity (investor's mind)," "physical and economic value (of environmentally friendly real estate)," and "(environmental) regulations and systems." This paper intends to provide a normative presentation of the economic value of green buildings, the second of the three viewpoints.

There has been a large accumulation of analytic studies on the relationship between environmental and real estate value. For example, when air pollution became an important social and economic problem, the relationship between air pollution levels and real estate prices was analyzed (Shimizu, 2004b); when road and other traffic noise became a social problem, the relationship between noise levels and real estate prices was studied (Shimizu, 2004a); and when the importance of greenery in urban cities began to be appreciated, the relationship between the amount of greenery or general orderliness in urban cities and real estate prices was examined (Tanishita, Hasegawa, and Shimizu, 2009). All these studies were intended to evaluate how real estate prices are affected by the surrounding environment. Their main purpose was, in other words, to measure through the real estate market the economic value of certain environmental qualities that were not explicitly traded in the market. Economically, they were designed to measure the economic value of external or highly public goods.

[3)] According to the Kyoto Mechanisms introduced by the Kyoto Protocol, or the first international framework for environmental issues, Japan was obligated to reduce its carbon dioxide emissions by 6 percent as compared with the base year, 1990. Results for 2007 showed, however, a 9 percent increase from the base year.

When it comes to the economic value of green buildings, however, the analysis must take on a very different structure. Green buildings are environmentally friendly themselves and do not depend on the externality of their surroundings. The economic value of green buildings must therefore be measured based on the value of the externality of the buildings themselves.

Attention should be paid to the fact that this externality is basically negative, not positive. “Green” merely refers to a relatively small impact on the environment and does not mean that the building itself has positive externality. In the environmental market, buildings basically offer high levels of negative externality, and green buildings are called “green” simply because their negative externality is relatively small. In other words, the amount of greenery can be increased to build up social accumulations of positive externality, whereas green buildings, if increased, still place a burden on the environment. This issue could safely be compared to a social problem caused by a factory that discharged air pollutants and impaired the health of community residents; for the issue under review, the “air pollutants” are carbon compounds and the “community residents,” or the health victims, are the earth, but the overall structure is the same. Taken this way, it would be easy to imagine there is a need for social responses to buildings that discharge carbon compounds.[4)] Also, as this issue has become a global one, it must be addressed quickly not just by Japan, but by the entire international community (for more details, see Takagi and Shimizu, 2009).

If real estate is taken as something that produces a negative externality to society by discharging carbon compounds, then the structural issue is similar to that of air pollution, which gave rise to numerous lawsuits during Japan’s high-growth period. Accordingly, owners, users, and investors must all be well aware of the attendant environmental risks.

Given the above points, how much value, if any, does the market place on green buildings? And if the market does place value on green buildings, through what mechanism are they differentiated?

This paper is intended to provide a review of the economic value of green buildings and analyze how much value the concept of environmental friendliness actually adds to buildings.

In Chapter 2, the author uses prior studies to elucidate how green buildings produce economic value. In addition, based on the results of the demonstration analysis by Yoshida and Shimizu (Yoshida and Shimizu, 2010), the author describes suggestions that could be offered to Japan’s real

---

[4)] An examination of the increase in carbon emissions from the base year of 1990 shows that about one third of total emissions is accounted for by “business and other sectors” (including offices) and the “household sector” (including houses) and that emissions from both sectors in 2007 were more than 40 percent higher than the base year levels.

estate market.

In Chapter 3, the author presents conditions that should be met for green buildings to produce economic value in Japan. In so doing, the author assumes green buildings have already been valued in the real estate market to some extent, but that their realized economic value is still smaller than their actual socioeconomic value. The author then examines what market infrastructure would be necessary to fully realize the economic value of green buildings in Japan, citing other countries' experiences.

In the last chapter, "A low-carbon society and the real estate market," the author discusses how the real estate market would be affected once social systems relating to environmental issues have changed.

2. How green buildings produce economic value

2.1. How real estate prices are determined

It would be helpful to review how real estate prices are determined before examining the economic value of green buildings. Basically, people own real estate to acquire either certain services or a certain investment value. An economic value in the user market arises once the rental rate is determined, while investment value in the capital market is determined by rebating future rent as determined by the user market at a certain rate of return. This can be expressed by formula (1) below:

$$p_{it} = \frac{y_{it}}{R_{ft} + R_{pi} - r} \tag{1}$$

y_{it} : Rental income after expenses are deducted
R_{ft} : Return on investment for a safe asset
R_{pi} : Risk premium
r : Rate of increase in macroscopic income

Of course, formula (1) is predicated on the perpetual ownership of real estate. If a piece of real estate is sold, the price is determined by adding the expected price at the time of sale to the present value of income that accrued during the holding period (Discounted Cash Flow, or DCF). In other words, the basic pricing structure has two major elements: rental income after expenses are deducted, and the discount rate.

For rental income, while market standards generally exist in each region, determined by supply and demand, actual rent for an individual asset is also determined by its size and age, access to the nearest railway station and commercial facilities, the surrounding environment, and other attributes.

The discount rate, or the return expected from an investment, is determined through a comparison of risks involved. In other words, if the discount rate is determined as a result of asset selection, it is obtained by deducting the future growth rate from the sum of the return on investment for a safe asset and the risk premium (Gordon, 1959). The risk premium for real estate can be calculated by formula (2) below.

$$R_p = f\left(L(z_i), \xi\right) \tag{2}$$

L : Liquidity risk

ξ : Unforeseeable risk

The risk premium for a real estate investment is composed of liquidity and unforeseeable risks. The liquidity risk is said to be higher for real estate than for stocks and other assets, and the magnitude of this risk has been clearly demonstrated during the latest financial crisis.[5)]

2.2. Green buildings and their value as real estate

Next we turn our attention to the rental income produced by green buildings. Overseas studies have shown that relatively high office rents can be asked for green real estate. For example, a demonstration study of a U.S. office market (Eichholtz et al., 2009) indicated that green labels, or labels indicating environmental friendliness, increased rental income by slightly less than 3 percent and the effective rent, an index which takes expenses into consideration, by around 6 percent. Another study (Fuerst et al., 2009) showed a utilization rate increase of between 3 and 8 percent for green buildings. It has also been reported that rental rates, utilization rates, and selling prices are all positively influenced by green labels (Wiley et al., forthcoming). For the housing market, an older

5) It is easily expected that liquidity also changes according to the features of real estate. See Shimizu and Kawamura (2009) for a demonstration analysis that explains the features of real estate, as well as the rent, the price and the discount rate.

piece of research (Dian and Miranowski, 1989) showed that housing prices go up as energy efficiency rises, and another study (Banfi et al., 2005) reported that residential house tenants are willing to pay up to 13 percent more to rent energy-saving buildings.

It has thus been demonstrated that rental income, utilization rates, and prices are higher for real estate that has been certified as environmentally friendly and has a green label.

Due to its short history and limited data availability, the impact of green labels on real estate prices in Japan has only been examined in two analytical studies (Ministry of Land, Infrastructure, Transport and Tourism, 2010, and Yoshida and Shimizu, 2010).[6)] The study by Yoshida and Shimizu, conducted on the new condominium market in Tokyo, showed using hedonic analysis how new condominium prices are affected by green labels, based on data from environmental performance assessment reports for condominiums in Tokyo.[7)]

The studies showed around 5 percent higher prices for green condominiums whose environmental performance assessment reports have been disclosed. It was also shown that the effect of green labels was remarkable in 2006 or 2007 and disappeared in 2008. This is suggestive of many issues. First, in markets that provide high environmental performance and are recognized by consumers, the price is much more likely to be higher. In competitive markets where sellers are predominant, green features can be reflected in the price, whereas in buyer-dominated markets, it is difficult to raise the price during unsettled periods following financial crises, such as in 2008. More careful analysis is needed for 2008, however, as the markets faced exceptional conditions in the wake of the financial crisis.

These increases in rental income and prices reflect users' expectations of cost-saving effects: even if they have to pay a higher rent, there would substantially be no additional burden due to a decrease in environment-related expenses (e.g., water, electricity, and heating expenses) incurred as they use the real estate. And, if equipped with PV systems such as smart grids, green buildings can produce and sell energy, and this would add to the savings effect. Thus, when we examine investments in green buildings, we need to consider direct benefits, such as the ability to increase rents and other prices due to cost-saving effects, separately from other issues.

[6)] Several demonstration studies were conducted on how housing prices are affected by certain signals, such as the availability of housing performance assessment reports and the renovation history. For example, see Harano, Nakagawa, Shimizu, and Karato (2009).

[7)] This reporting system, introduced in October 2005, requires that information about four assessment items prescribed by the Tokyo metropolitan government be prepared and disclosed for new buildings or enlargements that exceed 10,000 square meters in total floor area. The assessment items are (1) the building's heat insulation efficiency, or the reduction of the building's thermal load, (2) the equipment's energy efficiency, or the introduction of energy-saving equipment, and (3) the building's long life, and (4) greening.

Some have questioned the cost-saving effects of green buildings. Constructing green buildings requires making as large an initial investment as necessary in order to provide the intended green features. Because the size of future repair investments is proportional to that of the initial investment, a larger initial investment means that greater maintenance and repair investments will be required over short and medium-to-long investment periods. In this case, an important question is the correlation between the size of the initial and maintenance/repair investments and the rent-increasing effect adjusted by cost savings to be achieved during the investment period. Unfortunately, no objective, reliable data is available in this regard. As a result, such uncertainty accompanied with green features not only makes it impossible to guarantee direct increases in net income, or income after expenses are considered, but also affects the discount rate.

To consider how the discount rate is affected, it would be helpful to review studies of socially responsible investment funds. Some argue that socially responsible investments can produce higher returns than ordinary ones. For the effects of these investments, however, different research results have been presented, partly because of the different periods analyzed (for example, Renneboog and Zhang, 2008 and Galema et al., 2008). Even if profitability is not high, the discount rate is expected to decline as the amount of risk decreases, provided that volatility is low. Thus, the economic value would rise as the risk level fell. At the moment, however, there is insufficient research data to support this hypothesis.

In the meantime, given that indexes of only green buildings are now available (Newell, G, 2009), the number of ecology-conscious investors is increasing (Barnea, Heinkel, and Kraus, 2005), and environmental awareness is growing in the Asian region, where real estate investment activities are relatively brisk (Chan, Qian, and Lam, 2009), it is more likely than before that the expected effects of lower risk will be realized in a specific form.

3. Conditions for green buildings to be fairly valued by the market

3.1. Green labels and the real estate market

How will green buildings ultimately be valued by the market? What conditions should be in place for green buildings to produce economic value? There must be certain market conditions in place for green buildings to produce economic value. In the case of real estate investment, any systemic change will have a strong impact on investment performance, so it is very important to know what types of change will have a specific impact on the market. Behind this lies the assumption that the level of economic value now awarded by the market is lower than socially expected. The following is a normative analysis of this effect.

In order for the inherent economic value of green buildings to be realized in the market, it is necessary, first of all, that information about the green features of real estate be accumulated, disclosed, and distributed. In addition, market participants who have acquired such information need to change their behavior.

If an investment is defined as an act that produces a certain economic value, it is possible to say that we invest in real estate not as a "physical matter," but as a "mass of information." Both individual households that invest in houses and enterprises that invest in large office buildings see the "physical matter," but its value cannot be measured accurately based on a "physical" review. Not until information relating to the "physical matter" is scrutinized can its value be determined precisely. In other words, we invest in real estate as a "mass of information."

Real estate information can be roughly divided into (a) information about the building's economic performance, such as income and expenses, and (b) information about its architectural performance. Architectural performance information consists of information about public regulations (concerning construction techniques, earthquake resistance, etc.) and environmental regulations (concerning soil contamination, the use of asbestos, etc.). For investment assets, such information is often obtained from engineering reports, while for residential houses, it is available from documents describing important matters or housing performance assessment reports, the latter of which are becoming increasingly common.

Market participants implicitly change their behavior on the basis of this information. The first thing that is necessary to transform their behavior is to include specific information about green buildings in this mass of information and to disseminate this information widely.

Recent years have seen the increasingly widespread use of an information disclosure system that describes the environmental burden imposed by each piece of real estate. The Japanese system is called CASBEE, while overseas countries have certification systems such as BREEAM in the U.K. and LEED in the U.S. These systems are outlined in Table 1.

These environmental assessment standards are intended to measure the environmental burden that is potentially produced by a given piece of real estate. In Japan, certification is prescribed for development projects of certain sizes by the local government authorities.

Not until this certification system and the disclosure of such information become widespread will market participants' behavior in the real estate market be transformed and the economic value of green buildings incorporated into the pricing mechanism. Information disclosure alone, however, will not change the behavior of market participants. To influence their behavior, the disclosed information needs to be both accurate and widely recognized.

Obviously, inaccurate information cannot be relied upon by market participants, but even accurate information will not transform their behavior unless it is recognized as useful. "Recognizing information" means that information must be so clear and simple that it cannot fail to be recognized. There are tradeoffs between these conditions. A more accurate assessment of environmental performance, for example, will require a wider range of yardsticks.[8)]

For example, the U.K.'s BREEAM evaluates many environmental features, including (1) energy efficiency (carbon dioxide emission), (2) water use efficiency, (3) materials used in the building, (4) indoor environment (comfort and health for workers), (5) environment available on site, (6) accessibility, (7) management status, (8) contamination status, and (9) impact on the local ecology. The assessment results are therefore not so easy for general market participants to interpret. Japan's CASBEE is more precise and accurate than the other assessment systems because it evaluates buildings in terms of BEE (Building Environment Efficiency), that is their "environmental quality (Q)" and "environmental load (L)." A question remains, however, whether comprehensive indices, such as BEE, are viewed by market participants (including investors) as linked to market value or if they are easily "recognized." In other words, these indicators only describe the physical condition of buildings and are not intended for conversion into a specific market value.

What more specialized investors are interested to know may not be how much potential a particular building has to be environmentally friendly, but what effects are being produced as it is actually managed or how sustainable the building will be over the long term.

[8)] Shimizu (2008) points out four conditions to be met by real estate information: (a) accuracy, (b) recognition, (c) versatility, and (d) simplicity and clarity.

Table 1　Types of Green Labels

Environmental standard	Country	Year of introduction	Developer/ provider	Feature
BREEAM (BRE Environmental Assessment Method)	U.K.	1990	BRE (Building Research Establishment), ECD (Energy and Environment)	This system sets forth individual assessment standards for a wide range of subjects, from buildings, such as offices, commercial facilities, stand-alone houses, collective housing, schools, distribution facilities (warehouses) and courthouses, to communities. Although they are assessed differently, common standards are (1) energy efficiency (carbon dioxide emission), (2) water use efficiency, (3) materials used inside the building, (4) indoor environment (comfort and health for workers), (5) environment available on site, (6) accessibility, (7) management status, (8) contamination status, and (9) impact on the local ecology. Having started with assessments in the planning and development stages, this system has evolved to cover the management stage as well.
LEED (Leadership in Energy and Environmental Design)	U.S.A.	1996	U.S. Green Building Council	The basic concept is the same as for BREEAM. Initially intended for application in the design and development stages, this system is now comprehensive, also covering the management stage. Evaluation standards are (1) energy efficiency, (2) water use efficiency, (3) resource use efficiency and externality, (4) design, (5) respect for the landscape, and (6) environmental quality.
CASBEE (Comprehensive Assessment System for Built Environment Efficiency)	Japan	2001	IBEC (Institute for Building Environment and Energy Conservation)	The basic concept is the same as for BREEAM. Providing basic tools for design, development, existing buildings, and repair, this system sets forth standards for a wide range of subjects, from buildings to city planning. Although evaluation standards are much the same as under BREEAM and LEED, this system is unique in that buildings are assessed in terms of BEE (Building Environment Efficiency), comprised of their environmental quality (Q) and environmental load (L).
IPD: Environmental Code	U.K.	2007	IPD (Investment Property Databank)	While BREEAM, CASBEE, and LEED are focused on the potential functions of buildings, the Environmental Code focuses on their actual use status. Assessment standards are (1) energy efficiency, (2) water use efficiency, (3) waste disposal efficiency, (4) accessibility, (5) equipment, (6) indoor environment, and (7) adaptation to changes in the global environment.
IPD/IPF: Sustainable Property Index	U.K.	2009	IPD (Investment Property Databank), IPF (Investment Property Forum)	Information affecting investment performance was drawn from the IPD Environmental Code and converted into an investment performance index. The extracted assessment standards are (1) building quality, (2) accessibility, (3) energy efficiency, (4) water use efficiency, (5) waste disposal efficiency, and (6) flooding risk.

Source: http://www.breeam.org/ for BREEM; http://www.usgbc.org/DisplayPage.aspx?CategoryID=19 for LEED; http://www.ibec.or.jp/CASBEE/ for CASBEE; http://www.ipdoccupiers.com/Default.aspx?TabId=1632 for the IPD Environmental Code; http://www.ipd.com/Default.aspx?tabid=2215 for the IPD/IPF Sustainable Property Index.

It is true that green features are one of the important elements of a building’s sustainability. In order for real estate to maintain its value in the market, however, it must possess green features in a broader sense. Unfortunately, current environmental assessment systems include unnecessary standards. BREEM, CASBEE, etc., are technical standards for assessing the potential environmental features of buildings and are not designed to show how they are actually managed or provide information directly linked to their investment value. In this context, the U.K. established rules for the accumulation and disclosure of real estate information in order to assess actual real estate management practices using environmental indicators and thereby understand the overall sustainability of the property.

The Environmental Code, released in the U.K. in 2007, is unique in that it measures the environmental load placed by real estate in terms of its actual use, whereas BREEAM, CASBEE, and LEED are focused on its potential functions. The standards set forth by the code are (1) energy efficiency, (2) water use efficiency, (3) waste disposal efficiency, (4) accessibility, (5) equipment, (6) indoor environment, and (7) adaptation to changes in the global environment. This code is quite different from the other environmental labeling systems in that it was formulated by investors rather than architectural engineers, thus it is more focused on measuring the investment value of real estate.

OSCAR (Open Standards Consortium for Real Estate), a promoter of the standardization of real estate information, included environment-related items in their real estate information standardization code (according to a press release on April 22, 2010).[9)]

Now that the Environmental Code is in force and environmental features are included in OSCAR, a standard for real estate information accumulated in actual real estate operations, real estate managers will accumulate environmental information in their day-to-day operations. It should be noted here that information is accumulated in accordance with standardized rules. Environmental information furnished by real estate managers hardly transforms the behavior of market participants as long as it is developed and disclosed under varying standards. Under the OSCAR standard, market participants can “compare” figures showing the actual green features of real estate and appreciate the information properly. As a result, the conditions mentioned above, i.e., “versatility,” “clarity,” and “simplicity” of information, are now being met. These information standards can cause a change in market behavior, which in turn can lead to more accurate economic values being assigned to real estate.

9) There were two standards for real estate information: PAICES, applied mainly in the U.K., and OSCAR, used primarily in the U.S. These two codes were integrated into one, whose name is OSCAR but whose contents are substantially based on PAICES. For OSCAR, see http://www.oscre.org.

In 2009, the IPD/IPF Sustainable Property Index was published. Information that affects investment performance was drawn from the IPD Environment Code and converted into an investment index. The extracted assessment standards are (1) building quality, (2) accessibility, (3) energy efficiency, (4) water use efficiency, (5) waste disposal efficiency, and (6) flooding risk. The development of such an index implies that the future discount rate will be affected by green features. It allows investors to compare indexes of green and other buildings in terms of volatility, etc., and clearly understand spreads in the amount of risk and investment performance.

With such information standards in place, the economic value of green buildings will be realized more accurately. This suggests that an information divide will result between real assets supported by this type of information and those that are not, thus leading to a disparity in investment values.

3.2. Green building and CSR

Green buildings must be valued not only in the real estate market, but in the broader economic market as well. On the day after the IPD Environmental Code was released, the *Financial Times* commented that if green real estate is owned and used by a company, eco-friendliness may be reflected in the company's "corporate value" as well as in the value of the real estate itself.[10)] To address this issue, it would be helpful to review studies of the effects of green labels in markets other than the real estate sector.

Teisl, Roe and Hicks(2002) analyzed the effects of green labels for canned tuna products. This study suggests that a dolphin mark, which certifies the non-inclusion of dolphin meat, not only transforms consumer behavior in the canned tuna market, but also shows the company's respect for the protection of dolphins, thus increasing its corporate value. There has also been a study on the value of eco-consciousness in corporate plant investment (Amacher, Koskela and Ollikainen, 2004). In general, equipment with high environmental efficiency costs more and negatively affects the operator's return on investment. The researchers point out, however, that because green investment has externality, once it is internalized in the market, companies will find that green investment yields a positive value. In other words, if real estate is taken as equipment in its broadest sense, such externality effects mean that green investment in real estate can contribute to corporate value.

[10)] Financial Times, 2008.2.22, U.K. Edition.

Similar externality effects of eco-conscious buildings can be seen in the real estate market as well. One analysis of the corporate tenants of green buildings (Eichholtz et al., 2009) suggests that companies with a stronger preference for green buildings can be classified into six groups: (a) companies in the tertiary industry that can increase profit by cutting energy expenses, (b) companies that have been requested by their shareholders to commit to CSR activities, (c) companies sensitive to environmental issues (to overcome a negative image), (d) companies with highly educated personnel who create high added value, (e) government or public agencies, and (f) companies sensitive to consumer behavior.

These companies pay higher rents not just because they want to enjoy the benefit of direct cost saving, including higher energy efficiency as in (a), but also because it is a rational action in pursuit of an externality that arises somewhere other than in the real estate market.

4. Conclusion: A low-carbon society and the real estate market

Real estate can be viewed as an element of production for enterprises and a basis of living for households; for both parties, it is an indispensable resource. The real estate market should therefore play an active role in worldwide efforts to realize a low-carbon society. In this context, it can easily be seen that expectations for green buildings will only increase over time.

As discussed above, however, even green buildings do not have a positive impact on the environment; they continuously produce negative externality in the sense that they discharge carbon compounds. Since green buildings have such features, people who own, use, and invest in them must try to reduce their negative externality as much as possible. This does not just mean externality in the sense of the environment, but includes issues such as respect for landscapes and communities.

Economics textbooks teach that the absorption of negative externalities and convergence toward a socially optimum supply level can be achieved by imposing taxes on entities that produce negative externalities, and by granting financial aid to entities with positive externalities, in other words, by regulating the market.[11)]

For the real estate market, implementing an environmental policy means promoting "environmental regulation" in its broader sense. When earthquake resistance was recognized as a

[11)] This is known as the Pigovian regulation.

major issue, the Building Standards Act was revised to specify aseismic standards, and phrases such as “new aseismic standards” and “old aseismic standards” were newly coined. It is therefore likely that sustainability in the market will depend on its conformity with environmental standards. If the market changes in this way, liquidity for nonconforming properties will not just decrease but evaporate. Put another way, the economic value of green buildings is not represented by higher rents, lower costs, or lower discount rates alone. Rather, when viewed in the medium-to-long range, the true economic value is avoidance of the risk of being excluded from the market due to nonconformity with environmental standards, just as buildings that failed to meet aseismic standards were no longer liquid in the investment market—in other words, it relates to the avoidance of exposure to heavy taxes or levies.

What all participants in the real estate investment market should be aware of is that real estate is physical matter that continues to give society negative externality by discharging carbon compounds. Real estate owners, users, and investors must recognize that this issue is identical in structure and nature to that of air pollution, which gave rise to many lawsuits in Japan’s high-growth period, and accurately understand the environmental risks involved in owning, using, and investing in real estate. This issue has already come to be recognized in Europe.

At an international convention held in November 2009 at Brighton, U.K., a famous consultant said, “When we take a look at the coming 10 years, we will be faced with a new risk: the environment.”[12] Japan may also be faced with this new risk in the near future.

[12] A speech by Richard Barras, President of Property Market Analysis, at the IPD/IPF Property Investment Conference 2009 (Brighton, U.K., 26-27 November, 2009).

References:

・Amacher, G.S, Koskela, E., and Ollikainen, M. (2004), “Environmental quality competition and eco-labeling,” *Journal of Environmental Economics and Management*, Vol. 47, pp. 284-306.

・Banfi, S., Farsi, M., Filippini, M., and Jakob, M. (2005), “Willingness to Pay for Energy-Saving Measures in Residential Buildings," *CEPE Working Paper*, No. 41.

・Barnea, A., Heinkel, R., and Kraus, A. (2005), “Green investors and corporate investment,” *Structural Change and Economic Dynamics*, Vol. 16, pp. 332-346.

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

・Dian, T.M., and Miranowski, J. (1989), “Estimating the Implicit Price of Energy Efficiency Improvements in the Residential Housing Market—A Hedonic Approach,” *Journal of Urban Economics*, Vol. 25, pp. 52-67.

・Eichholtz, P., Kok, N., and Quigley, J.M. (2009), “Doing Well by Doing Good? Green Office Buildings,” *Berkeley Program on Housing and Urban Policy Working Papers*, W08-001.

・Eichholtz, P., Kok, N., and Quigley, J.M. (2009), “Why Do Companies Rent Green? Real Property and Corporate Social Responsibility,” *Berkeley Program on Housing and Urban Policy Working Papers*, W09-004.

・Fuerst, F., and McAllister, P. (2009), “ An Investigation of the Effect of Eco-Labeling on Office Occupancy Rates,” *Working Papers in Real Estate & Planning* (University of Reading), No. 2009-08.

・Galema, R., Plantinga, A., and Scholtens, B. (2008), “The stocks at stake: Return and risk in socially responsible investment,” *Journal of Banking & Finance*, Vol. 32, pp. 2646-2654.

・Gordon, M.J. (1959), “Dividends, Earnings, and Stock Prices,” *The Review of Economics and Statistics*, Vol. 41, pp. 99-105.

・Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism of Japan (2010), “Research Report of the Workshop for Considering the Value of the ‘Environment’ for Real Estate,” Ministry of Land, Infrastructure, Transport and Tourism.

・Harano, K., Nakagawa, M., Shimizu, C. and Karato, K. (2009), “Housing Price and Renovation under Information Asymmetry,” *CSIS (University of Tokyo) Discussion Paper*, No. 94.

・Newell, G., (2009), “Developing a socially responsible property investment index for UK property companies,” *Journal of Property Investment & Finance*, Vol. 27, pp. 511-521.

・Renneboog, L., Horst, J.T., and Zhang, C. (2008), “Socially responsible investments: Institutional aspects, performance, and investor behavior,” *Journal of Banking & Finance*, Vol. 32, pp. 1723-1742.

・Shimizu, C. (2004a), “Impact of Road Traffic Noise on the Housing Price,” *Real Estate Market*

Analysis, Shimizu, Chihiro, Jutaku Shimposha, Chapter 8, Section 2.

・Shimizu, C. (2004b), "Impact of Air Pollution on the Housing Price," *Real Estate Market Analysis*, Shimizu, Chihiro, Jutaku Shimposha, Chapter 8, Section 3.

・Shimizu, C. (2008), "Impact of the Financial Instrument and Exchange Act on the Real Estate Market," *Journal of the Japan Association for Real Estate Sciences*, Vol. 21, No.4 (No.83), pp. 62-69.

・Shimizu, C. (2009), "Estimation of Hedonic Single-Family House Price Function Considering Neighborhood Effect Variables," *CSIS (University of Tokyo) Discussion Paper*, No. 93.

・Shimizu, C., and Kawamura, Y. (2009), "Real Estate Features and Cap Rates," *Synopsis for the 2009 Autumn National Conference of the Japan Association for Real Estate Sciences*, pp. 193-200.

・Shimizu, C., and Nishimura, K.G. (2007), "Pricing structure in Tokyo metropolitan land markets and its structural changes: pre-bubble, bubble, and post-bubble periods," *Journal of Real Estate Finance and Economics*, Vol. 35, No. 4, pp. 495-496.

・Shimizu, C., Nishimura, K.G., and Asami, Y. (2004), "Search and Vacancy Costs in the Tokyo housing market: Attempt to measure social costs of imperfect information," *Regional and Urban Development Studies*, Vol. 16, No. 3, pp. 210-230

・Shimizu, C., Nishimura, K.G., and Karato, K. (2007), "Nonlinearity of Housing Price Structure: the Secondhand Condominium Market in the Tokyo Metropolitan Area," *CSIS (University of Tokyo) Discussion Paper*, No. 86.

・Tanishita, M., Hasegawa, K., and Shimizu, C. (2009), "Impact of Landscape Regulations on Housing Prices – A Verification Study in Setagata-ku, Tokyo, by the Hedonic Approach," *Keikaku Gyosei*, Vol. 32, No. 2, pp. 71-79.

・Teisl, M.F., Roe, B., and Hicks, R.L. (2002), "Can Eco-Labels Tune a Market? Evidence from Dolphin-Safe Labeling," *Journal of Environmental Economics and Management*, Vol. 43, pp. 39-359 .

・Wiley, J.A., Benefield, J.D., and Johnson, K.H. (2009), "Green Design and the Market for Commercial Office Space," *Journal of Real Estate Finance and Economics*, (forthcoming).

・Yoshida, J., and Shimizu, C. (2010), "Impact of Green Buildings on Real Estate Price: A Case of New Condominiums in Japan," *CSIS (University of Tokyo) Discussion Paper*, No. 106.

Appendix: Impact of Green Buildings on Real Estate Price

As mentioned above, the paper by J. Yoshida and C. Shimizu (2010) ("Impact of Green Buildings on Real Estate Price: A Case of New Condominiums in Japan," *CSIS (University of Tokyo) Discussion Paper*, No. 106) used the hedonic approach to elucidate the effects of green labels and their rating under the Tokyo metropolitan government ordinance concerning the environmental performance of condominiums in the Tokyo condominium market. The estimations from this study (the first to measure the economic value of green buildings in Japan) are extracted below, which provide many interesting findings, and serve as the basis of the present paper.

I. Green building and housing price

Hedonic model and data

Prior to collecting data needed to analyze the impact of green buildings on housing price, we examine the pricing mechanism for green buildings. The value of a house changes according to factors such as number of rooms, balcony size, toilet facilities, kitchen and bathroom facilities, earthquake resistance, and other attributes. In particular, residential houses are priced in a differentiated market according to performance and functionality because each is unique (in other words, no other goods are totally equivalent in terms of location, etc.). The most effective method for analyzing such a market is the hedonic approach, which considers market value as a group of various performance and functional values (a group of attributes) and estimates the product price using statistical regression analysis. The price is expressed by an equation consisting of the attribute groups, which is known as the "hedonic price function." Using this function, we can estimate the amount of value that consumers attach to each type of function and performance.

This study is intended to compute the economic value of the green features of environmentally friendly buildings, using the hedonic approach. Specifically, the pricing mechanism for new condominiums is defined as follows:

$$PC_{i,j} = f\left(G_i, X_{i,j}, A_k, C_l\right) \qquad (1)$$

$PC_{i,j}$: Price for condominium unit j in new apartment building i

G_i : Green label for apartment building i

$X_{i,j}$: Architectural characteristics of condominium unit j in apartment building i

A_k : Characteristics of the ambient environment of district k

C_l : Locational characteristics of area l

In general, the condominium unit price is affected by differences in the unit's performance, including its "proprietary area" and "number of rooms," as well as by accessibility, including "proximity to the nearest railway station," and the apartment building's performance, including its structure ($X_{i,j}$). The environmental performance of the building is included in this group of attributes. The price is also influenced by the characteristics of the surrounding environment, such as the local atmosphere and commercial zones (A_k). This is known as the "neighborhood effect." If an analysis is performed across a wide area covering more than one administrative ward, attention must also be paid to differences across a wider area, such as "proximity to the central business district (CBD)" and differences in administrative services available at the regional level. Many prior studies have indicated that there are also disparities by railway line, along which some cities in Japan have been developed. Therefore, attention is also paid to differences in environmental features across a wider area than the neighborhood (C_l).

Next we will prepare and organize our data according to the concepts as defined above.

Data overview

When estimating the impact of green labels on housing price, we use the hedonic approach to control for the various attributes of the condominium. In this section, we explain green labels (G), the condominium unit price (PC), the attributes of the condominium unit and building (X), the surrounding environment (A), and the locational features (C) pursuant to the preceding section.

(1) Green label (G)

We analyzed green labels based on information disclosed under the Tokyo metropolitan government's program for assessing the environmental performance of condominiums.[13)] In Tokyo, the owners of large apartment buildings, including new ones, are required to submit building environment plans to the metropolitan government. Based on the building environment planning system introduced in 2002, this program has required since October 2005 that information about four assessment items prescribed by the Tokyo metropolitan government be prepared and disclosed for construction or extension of buildings that exceed 10,000 square meters in total floor area.[14)] The

---

13) For details, see http://www7.kankyo.metro.tokyo.jp/building/mansion/index.html.

14) The program was revised in January 2010 to cover leased condominiums as well as condominium units for sale, and further revised in October 2010 to increase coverage by lowering the total floor area threshold to 5,000 square meters. A voluntary reporting program will be introduced under which the owners of apartment buildings with a total floor area of more than 2,000 square meters but not more than 5,000 square meters may also use green labels.

four assessment items are (1) the building's heat insulation efficiency, (2) the equipment's energy efficiency, (3) the lifespan of the building, and (4) greening.[15)] For each of these items, buildings are rated on a scale of one to three stars. Also, to ensure the ratings are recognizable to consumers, they must be indicated on all advertisements with plans for condominium units (including inserts, direct mail, and Internet advertisements) for which building environment plans have been submitted. In this way, these ratings can actually influence the behavior of consumers.

A data breakdown by assessment item showed that for heat insulation, there were no one-star buildings, while two- and three-star buildings accounted for 11.41 percent and 3.74 percent, respectively. As for energy efficiency, 0.74 percent received one star, 6.31 percent two stars, and 8.15 percent three stars. As for long life, one-, two-, and three-star buildings accounted for 0.31 percent, 12.96 percent, and 1.96 percent, respectively. For greening, 0.15 percent of buildings received one star, 3.51 percent received two stars, and 11.54 percent received three stars.[16)]

Very few buildings received one star, the lowest score. This means that the effect of this assessment is mostly confined to the combined effect of two and three-star ratings. And because the impact of the ratings on price is not necessarily linear, our estimation uses dummy variables created according to the number of stars received.

(2) Condominium unit price data (PC) and condominium unit and building (X)

Unlike in the U.S. and U.K., it is very difficult to obtain actual real estate prices in Japan. This study, therefore, uses real estate price data from an MRC database on asking prices for new condominiums[17)] and a transaction price database owned by Recruit Co., Ltd. Note that these two databases contain different types of information: the former shows asking prices as listed in pamphlets, whereas the latter contains actual transaction prices.[18)] Specifically, MRC's asking price database provides full market coverage, whereas the Recruit database contains only a limited number of transaction prices because it is based on questionnaire surveys.

First, in addition to the "proprietary area" feature, we create dummy variables for the layout as another feature of a condominium unit.[19)] Next, as the characteristics of an apartment building, we

[15)] In 2009, the program was revised to include another assessment item of "solar power generation and solar heat."
[16)] The total is not 100 percent because there are condominiums without green labels.
[17)] For details, see http://www.mrc1969.com/data/.
[18)] Recruit's new condominium price database is a collection of actual transaction prices written in the copies of contracts obtained from questionnaire respondents. For details of the questionnaire, see http://qqq.jj-navi.com/house/JJ/vcm2001/index8.html.
[19)] For this purpose, we defined a single-room unit dummy as including 1K, 1R, and 1DK. A large dummy was defined to include 2LDK, 3K, 3DK, 3LDK, 4DK, 4LDK, 5DK, and larger units. These dummy variables are identified on the basis of medium sizes

create variables relating to the "building structure,"[20] "land area," "total floor area," "time to the nearest station," and "means of transportation to the nearest station."[21]

It is widely known that selling prices in Japan's new condominium market are influenced by the brand power and credibility of developers and constructors. In addition, it is highly likely that condominiums with excellent environmental performance will be offered by the developers and constructors with the highest credibility and brand power. We thus create dummy variables for the developer[22] and the constructor[23] to control for their influence on the condominium unit price.

(3) Characteristics of the ambient environment (A)

The MRC database contains several characteristics of the ambient environment: the floor-to-area ratio (or a statutory limit), the building-to-land ratio, and zoning. In addition to these, we use variables showing the characteristics of the local atmosphere and local community, as follows:

As a variable for the characteristics of the local atmosphere, we calculate the building density (the number of building units), the average floor area, the standard deviation thereof, and the greening ratio for each specified 500 m x 500 m area.[24] This is because the neighborhood-level environment of a building is affected considerably by the use status of surrounding buildings as well as public facilities. In addition, as variables showing the characteristics of the local community, we use the ratio of a population aged 65 or above and the office worker ratio (persons engaged in special or technical jobs)[25], both taken from the 2005 national census.

(4) Locational characteristics (C)

We create a few variables to control for the wide-area locational conditions of the 23 wards of

---

1LDK, 2K, and 2DK. "K" stands for a kitchen, "D" for a dining room, and "L" for a living room. For example, "3LDK" refers to a unit with three bedrooms, one living room, one dining room, and one kitchen. This real estate classification system is unique to Japan.

[20] We created RC and SRC dummies, using steel-frame construction as the base.

[21] We created a bus dummy for busing areas.

[22] We created dummy variables for each of the developers identified from condominium brands: Mitsui Fudosan, Nomura Real Estate Development, Asahi Kasei Homes, Morimoto, Mitsubishi Estate, Sekisui House, Sumitomo Realty & Development, Tokyo Tatemono, Daikyo, DYNACITY, and Tokyu Land. Estimates are based on other developers.

[23] Construction companies were grouped into three. Large construction company dummies include Takenaka, Obayashi, Kajima, Shimizu, and Taisei. The second-tier dummy group includes Kumagai Gumi, Toda, Penta-Ocean Construction, Konoike Construction, Sato Kogyo, Mitsui Construction, Mitsubishi Construction, Sumitomo Construction, Nishimatsu Construction, and Haseko.

[24] These statistics were computed from the Tokyo Urban Planning Survey 2006. The survey data can be used as polygon data on a geographical information system (GIS). The statistics were calculated from the survey data on individual buildings or land.

[25] Persons engaged in special or technical jobs are generally called "white-collar workers." Because white-collar income is generally higher than blue-collar income, it can serve as an alternative variable for regional income.

Tokyo. First, we create a variable showing the locational conditions of a building in the urban area, as is used in urban economics, that is, "time from the nearest station to the terminal station."[26) However, because each of the 23 wards has remarkably different regional characteristics, which cannot be explained by the time or distance to the CBD, we use an "administrative ward dummy" to control for regional differences that are not observed at the administrative ward level, including disparities in administrative service. Furthermore, as regards Tokyo, it is important to consider areas along railway lines as regional units that are independent of the administrative wards to some extent. Housing prices are generally higher in areas along railway lines running in a southwesterly direction and lower in areas where the lines run in a northeasterly direction. The value of condominiums located in the same administrative ward is affected very much by which railway company owns the nearest station. We thus use a "railway line dummy." And in an analysis of a wide space, proximity to the city center and regional dummies alone may not be sufficient to absorb spatial characteristics, so we use the "latitude" and "longitude" of buildings, as was done by Jackson (Jackson, 1979).

Descriptive statistics

The data relates to new condominiums constructed in the 23 wards of Tokyo from January 2005 to March 2009. The number of collected samples is 82,270, including 80,207 asking samples and 2,063 transaction samples. Table 2 provides summary statistics.

The average condominium unit price is almost the same for total samples (¥52.77 million) and for asking samples (¥52.57 million), while it is around 15 percent lower for transaction samples (¥44.88 million). This suggests that actual transactions are not concluded at the asking prices, but at discounts from the asking prices.

The "proprietary area (FS)" and the "time to the nearest station (TS)" are almost the same for the two groups, while the "land area (LA)" and the "total floor area (CA)" tend to be smaller for transaction samples. The "time to terminal station (TT)" is 20 minutes for asking samples and 16 minutes for transaction samples, showing a tendency of increased actual transactions in the urban center.

[26)] For this purpose, seven terminal stations were selected: Tokyo, Shinagawa, Shibuya, Shinjuku, Ikebukuro, Ueno, and Otemachi. We checked the average time to each terminal during the day and used the shortest one.

Table 2 Summary Statistics

	Total Samples	Asking Samples	Transaction Samples
PC: Price of Condominium unit (10,000 yen)	5,277.20 (3,493.98)	5,257.43 (3,459.33)	4,488.82 (1,412.29)
FA: Floor Area (square meters)	68.26 (21.42)	68.24 (21.30)	67.52 (15.83)
PC/FS(10,000 yen)	77.24 (27.29)	77.01 (27.13)	67.92 (17.30)
LA: Land Area (square meters)	6,132.73 (8,226.95)	6,105.32 (8,285.60)	5,039.79 (6,282.26)
TA: Total Floor Area (square meters)	3,119.58 (4,593.35)	3,101.97 (4,561.27)	2,417.48 (2,985.05)
TS: Time to Nearest Station (minutes)	7.55 (4.29)	7.57 (4.29)	8.27 (4.19)
TT: Time to Terminal Station (minutes)	20.78 (76.453)	20.68 (76.04)	16.85 (57.79)
Number of Observations=	82,270	80,207	2,063

( ) : Standard Deviation

II. Demonstration analysis
Estimation model

For hedonic function calculation purposes, we estimate three demonstration models, Models 1 to 3, using expression (1). As explained above, the data includes asking and transaction samples. This study stacks them and estimates the difference between asking and transaction samples using a transaction dummy (TrD_i). In other words, we apply the hedonic price formula to the 82,270 samples (the sum of asking and transaction samples), while at the same time estimating the disparity between transaction and asking samples, using the 2,063 samples. It should be noted, however, that because of the limited number of transaction samples, this estimation is not accurate enough and statistically significant results are difficult to obtain.

The effect of green labels (G_i), which is the subject of this research, is estimated using several different types of dummy variables for green labels. First, we estimate the average effect of green labels independently of the environmental performance level and the time of transaction, then estimate how the effect of green labels changes with the time of transaction, using the cross term of the environmental performance level and the time of transaction. Next, we estimate how the effect of green labels changes with the type and positiveness of green features, using the ratings in each environmental performance assessment item. Finally, even if sellers ask for higher prices because of green labels or environmental performance offered, buyers or consumers may not accept the price differences and the final transaction prices may be almost the same as those for condominiums without green labels. By adding a cross term of green label ($\mathrm{G_i}$) and transaction dummy ($\mathrm{TrD_i}$), we can estimate both of them.

First, in Model 1, we analyze price gaps between condominiums with and without green labels under the Tokyo program, using a dummy for the environmental variable ($\mathrm{G_i}$) that shows whether or not these labels are obtained. The possibility of the effect of green labels being different between asking and transaction samples is represented by a cross term. The function form is a semi-logarithm, and square terms are added for some variables, such as the size of the building. This is intended to deliberately exclude the possibility of an alternative variable for building size being created because green labels are required for buildings whose total floor area exceeds 10,000 square meters. For explicated variables, the natural logarithm of the price per square meter of condominium unit is used. The results, therefore, provide a rough estimate of the percentage by which the price changes along with each variable.

In order to assess the impact of green labels on housing price, the following three estimation models are used:

Model 1

$$\log\frac{\mathrm{PC_{i,j,t}}}{\mathrm{FS_j}} = \mathrm{a_0} + \mathrm{a_1 G_i} + \sum_{\mathrm{n}} \mathrm{a_2 X^n_{i,j}} + \sum_{\mathrm{n}} \mathrm{a_3 A^n_k} + \sum_{\mathrm{n}} \mathrm{a_4 C^n_l} + \sum_{\mathrm{t}} \mathrm{a_5 TD_t} + \mathrm{a_6 TrD_j} + \mathrm{a_8 G_i TrD_j} + \epsilon_{\mathrm{j,t}}$$

Where

$\mathrm{PC_{i,j,t}}$: Price of condominium unit j in apartment building i at time t

$\mathrm{FS_j}$: Floor area of condominium unit j (square meters)

$\mathrm{G_i}$: Green label for apartment building i

$\mathrm{X^n_{i,j}}$: Architectural and locational characteristics of condominium unit j in apartment building i (n-th characteristics)

$\mathrm{A^n_k}$: Characteristics of the ambient environment in region k (n-th characteristics)

C_l^n : Characteristics of the spatial environment in region l (n-th characteristics)

TD_t : Time dummy (t = years 2005 to 2009)

TrD_j : Transaction dummy (1 for transaction price, 0 for asking price)

In Model 2, a cross term of G_i and TD is added to determine how the effect of green labels changes over time.

Model 2

$$\log\frac{PC_{i,j,t}}{FS_j} = a_0 + \sum_t a_{1t} G_i\, TD_t + \sum_n a_2 X_{i,j}^n + \sum_n a_3 A_k^n + \sum_n a_4 C_l^n + \sum_t a_5 TD_t + a_6 TrD_j + \sum_t a_{1t} G_i\, TD_t TrD_j + \epsilon_{j,t}$$

In Model 3, G_i, which represents the existence of green labels for the preceding models, is replaced by a dummy variable for ratings in each environmental assessment item in order to determine how price is affected by the level of positiveness for each such item.

Model 3

$$\log\frac{PC_{i,j,t}}{FS_j} = a_0 + \sum_n a_{1n} G_{ni} + \sum_n a_2 X_{i,j}^n + \sum_n a_3 A_k^n + \sum_n a_4 C_l^n + \sum_t a_5 TD_t + a_7 TrD_j + \sum_n a_{8n} G_{ni}\, TrD_j + \epsilon_{j,t}$$

Where

G_{ni} : Green label for apartment building i (n-th assessment item)

Estimation results

The estimation results are shown Table 3. For all models, the determination coefficient adjusted for degrees of freedom was as favorable as 0.845 or 0.846. Also, the estimation results were consistent with expected results for each estimated variable.

First, Model 1 showed that asking prices were around 4.7 percent higher for condominiums with green labels. The effect of green labels was determined after controlling for the effects of all factors, such as the building's size, quality, location and ambient environment, the condominium unit's characteristics, the time of transaction, the developer, and the constructor. Developers must have made additional investments to enhance the buildings' environmental performance; the reason was shown to be that they anticipated higher selling prices.

How much transaction prices were different from asking prices was estimated using a dummy variable that identifies transaction samples and a cross term for transaction price and environmental performance dummies. In other words, we estimated both the general difference in transaction price level and the difference in transaction price due to the difference in green rating.

The constant dummy for the transaction price was estimated at -0.051, which is statistically significant at one percent. This shows that actual transactions were concluded at prices around 5.1 percent lower than the asking prices. The cross term for transaction price and environmental performance dummies was estimated at -0.008, which is statistically on the order of 14 percent. It should be noted, however, that because transaction prices were available for only 373 of the condominium units with green labels, the statistical power is limited and the effects of green labels, if any, would hardly be significant. Further verification needs to be performed by checking robustness and using a sophisticated standard error estimation method. These estimation results are interpreted as follows. For condominium units with green labels, the gap between the asking and transaction prices was 0.8 percentage points larger, standing at 5.9 percent, but because a 4.7 percent premium was included in the asking price, the final transaction price was 3.9 percent (4.7 percent minus 0.8 percent) higher than that for condominium units without green labels. In other words, the effect of green labels was observed in the transaction price too.

Then, Model 2 was analyzed to measure the time effect. In 2005, the time effect was a negligible -0.9 percent for the asking price because the program just started in October the same year. This figure should be interpreted as showing zero effect, rather than a negative effect. In 2006 and 2007, however, offer prices included premiums of 5.3 percent and 5.6 percent, respectively, and in 2008, a slightly lower premium of 4.8 percent was included.

Estimates for transaction samples cannot be statistically significant because they were limited in number and allocated to each year of transaction, making the number of samples for each transaction year even smaller. In particular, there were only eight transactions for 2005, so the estimation results are not conclusive. For 2006 and 2007, the estimation results do not show that the difference between asking and transaction prices was affected by green labels; transaction prices were 5.3 to 5.6 percent higher for condominium units with green labels than for those without. In 2008, the price discount for condominium units with green labels was 3.6 percent greater, so the premium included in transaction prices was around 1.2 percent (4.8 percent minus 3.6 percent). The estimates for 2008 were shown to be statistically significant, although the number of transaction samples was as low as approximately 100.

Finally, Model 3 was examined to measure the effect of ratings in each environmental performance assessment item. Model 1 or 2 was used to estimate differences in effect due to the existence or nonexistence of green labels. Model 3 was used to estimate the effectiveness of each such rating.

The estimation results show offer price premiums for many assessment items. Price premiums for two-star and three-star buildings were 5.9 percent and 0.2 percent for heat insulation, 5.1 percent and 2.1 percent for long life, and 6.0 percent and 6.9 percent for greening, respectively. The difference in the offer price was greatest for greening. There was a discount, however, of 7.3 percent and 9.6 percent for two-star and three-star buildings, respectively, for energy efficiency.

Although statistical power is limited due to the limited size of transaction samples that were further divided, the estimation of the cross term shows the following. First, for long-life condominiums, the difference between asking and transaction prices was substantially smaller: those with two and three stars exhibited a transaction price premium of 10.4 percent (5.1 percent plus 5.3 percent) and 10.3 percent (2.1 percent plus 8.2 percent), respectively, when asking price premiums were included. The heat insulation feature did not influence at all or slightly reduced the difference between asking and transaction prices, so buildings with two stars in heat insulation showed a 6.8 percent transaction price premium (5.9 percent plus 0.9 percent). Interestingly enough, no premium was observed for three-star buildings. As regards greening, which increases the difference between asking and transaction prices, the transaction price premium was nil for buildings with two stars, but 3.5 percent for those with three stars (6.9 percent minus 3.4 percent). Energy efficiency increased the difference between asking and transaction prices by one to three percent, bringing a price discount of around 10 percent for both two- and three-star buildings when asking price discounts were included.

When compared with the results of a study by Yoshida et al. (2010) that analyzed different transaction price data, including those for secondhand property, the estimation results above were interesting as they are consistent with this study in some respects and not in others. First, the present study showed that green labels positively affected transaction prices, whereas the research by Yoshida et al. (2010) produced evidence to the contrary. The results of both studies are, however, generally consistent with each other with respect to the relative effect of each green feature; energy efficiency and greening have low or negative effects, while long life has the greatest positive effect.

One interpretation of this difference is that the life cycle cost (LCC) for purchasers may have affected the results. Long life, which by definition reduces future maintenance and renewal costs, promises a low future LCC to property holders and adds to the initial purchase costs. Greening, however, requires higher maintenance and management costs on the part of owners and, given this high future LCC, works to reduce the initial investment. In other words, the future costs of maintenance, management, and equipment renewal, which vary according to the type of the embodied green feature, are reflected (capitalized) in the present price.

The effect of green features on housing price is also influenced by government support, such as tax incentives and financial aid, and the satisfaction that consumers obtain from green features. Because present tax incentives and financial aid are not so effective, purchasers may have taken into consideration the positive effect that may be produced by future government support. Or it may be that consumers are simply willing to pay more for green real estate, regardless of the financial advantages they will receive.

Table 3　Estimation of the Hedonic Function with Green Labels Taken into Consideration (OLS)

Dependent Variable

ln (PC/FS): log price of condominium unit per square meter

Independent Variables	Model 1		Model 2		Model 3	
Property Characteristics	**Base**	**Cross Term: x TrD**	**Base**	**Cross Term: x TRD**	**Base**	**Cross Term: x TrD**
Constant	4.122***	-0.051***	4.126***	-0.051***	4.124***	-0.051***
Green Label	0.047***	-0.008	-	-	-	-
Green Label X 2005	-	-	-0.009***	0.037***	-	-
Green Label X 2006	-	-	0.053***	0.012	-	-
Green Label X 2007	-	-	0.056***	-0.003	-	-
Green Label X 2008	-	-	0.048***	-0.036***	-	
Heat Insulation–2 points	-	-	-	-	0.059***	0.009
Heat Insulation–3 points	-	-	-	-	0.002***	-
Energy Efficiency–2 points	-	-	-	-	-0.073***	-0.034
Energy Efficiency–3 points	-	-	-	-	-0.096***	-0.008
Long Life–2 points	-	-	-	-	0.051***	0.053
Long Life–3 points	-	-	-	-	0.021***	0.082*
Greening–2 points	-	-	-	-	0.060***	-0.057**
Greening–3 points	-	-	-	-	0.069***	-0.034
Unit Characteristics						
FA: Floor Area	0.002	***	0.002	***	0.002	***
FA^2	0.000	***	0.000	***	0.000	***
Studio (Base=Medium-sized)	0.142	***	0.141	***	0.143	***
Upscale (Base=Medium-sized)	-0.063	***	-0.064	***	-0.064	***
Building Characteristics						
Structure–Steel (Base=SRC)	-0.025		-0.024		-0.026	
Structure–RC (Base=SRC)	-0.005	***	-0.003	***	-0.005	***
LA: Land Area(s)	0.000	***	0.000	***	0.000	***
LA^2	0.000	***	0.000	***	0.000	***
TA: Total Floor Area(s)	0.000	***	0.000	***	0.000	***

CA^2	0.000		0.000		0.000	
TS: Time to Nearest Station (s)	-0.010	***	-0.010	***	-0.010	***
TS^2	-0.001	***	-0.001	***	-0.001	***
Bus: Bus Dummy	-0.274	***	-0.274	***	-0.272	***
Bus×TS	0.001	***	0.001	***	0.001	***
TT: Time to Terminal Station	0.000	*	0.000	**	0.000	
Area Characteristics						
FAR: Floor-to-Area Ratio	0.000	***	0.000	***	0.000	***
LAR: Lot Area Ratio	-0.001	***	-0.001	***	-0.001	***
Zoning 1 (Commercial)	0.007	***	0.006	***	0.009	***
Zoning 2 (Industrial)	-0.045	***	-0.047	***	-0.042	***
Density of Building Units*	0.000	***	0.000	***	0.000	***
Mean of Floor Area per Bldg*	0.000	***	0.000	***	0.000	***
Std. Dev. of Floor Area per Bldg*	0.000	***	0.000	***	0.000	***
Ratio of 65 years old or above*	0.158	***	0.157	***	0.167	***
Office Worker Ratio*	-0.014	***	-0.014	***	-0.017	***
Open Space Ratio*	1.210	***	1.196	***	1.233	***
Latitude, Longitude	Yes		Yes		Yes	
Location (Ward) Control	Yes		Yes		Yes	
Railway Line Control	Yes		Yes		Yes	
Construction Company Control	Yes		Yes		Yes	
Developer Control	Yes		Yes		Yes	
Time Control	Yes		Yes		Yes	
Adjusted R square=	0.845		0.845		0.846	
Number of Observations=	82,270		82,270		82,270	

***Significant at 10%, **Significant at 5%, ***Significant at 1%**
Significance is based on White Heteroscedasticity Consistent Standard Errors.
An (s) after a variable name indicates that the variable is demeaned.
TrD: Transaction Dummy