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Green Luxury Goods? The Economics of Eco-Labels in the Japanese Housing Market*

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Abstract

This paper aims to extend the existing evidence on the investment value of green buildings to international markets, specifically the residential market in Japan. Using a unique transaction database of condominiums in the Tokyo metropolitan area and a hedonic analytical framework, we find that green buildings command a small but significant premium on both the asking and transaction prices. This finding is consistent with results from other countries. As far as we are aware, this is also the first study of green buildings' economic value based on a hedonic model incorporating buyer characteristics. However, further analysis reveals that this premium is primarily driven by wealthy households that exhibit a higher willingness-to-pay for eco-labelled condominiums, both as a total amount and as a fraction of the total sales price. We therefore conclude that eco-labels are perceived as a luxury good in the Japanese housing market rather than a way to save money on lower utility bills.

Key Words:
Green building; green label; hedonic approach; offer price; bid price; market price function; omitted variable bias.
Journal of Economic Literature Classification Numbers:
G51; M14; D92.

1 Introduction

Sustainability research in real estate has reached a critical juncture. The seminal studies (Miller, Spivey, Florance, 2008[17], Fuerst and McAllister, 2011[9], Reichardt, Fuerst and Zietz, 2012[12] , Eichholtz, Kok and Quigley, 2010[6], 2011[7] and Eichholtz and Quigley

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2012[5] to name just a few) provided first valuable insights into the pricing of sustainable real estate. However, these studies are also characterised by important limitations. Firstly, they typically focus on specific sectors, in specific countries and over specific timeframes which means that their results may not be readily generalisable to other sectors, places and time periods. This is particularly relevant as the majority of studies were conducted using data from the US office market, possibly because of data availability. Secondly, these studies rely on a very small number of data sources (notably from the CoStar Group) which provide a great wealth of information on property characteristics but are rather limited regarding the environmental performance and general sustainability indicators.

Perhaps surprisingly, the residential sector has attracted a much smaller number of academic studies in this topic area, despite its large size and obvious relevance for both the general economy and sustainable development. The reasons for this lack of empirical evidence are not clear. Larger fragmentation of investors and a lower fraction of professional or institutional investment in the market driving the discourse around 'green value' may be a contributing factor. Also, housing markets are highly regulated and prone to inefficiencies in many countries which makes it more difficult to measure the contribution of sustainability and energy efficiency to prices and rents. Despite the by now widely accepted proposition that pricing incentives are more effective in reducing environmental harm than 'command and control' policies, (Requate and Unold (2003)[20], the housing market seems to be lagging behind other sectors in the establishment of green markets.'Green' financial instruments are also still not used widely in the residential sector which makes capitalization into the lump-sum house price the only channel for economic rewards of sustainability in many cases. As this poses a significant risk for any upfront investment in energy efficiency, 'green value' might not be readily observable in housing markets.

According to Kotchen (2006)[15], green markets can principally be understood as a form of a private provision of a public good and as such can have either beneficial or detrimental effects depending on technology, individual wealth levels and the initial level of the public good. This proposition has been evaluated empirically, for example by Jacobsen, Kotchen and Vandenbergh (2012)[20] in the context of residential electricity demand.
Despite these apparent obstacles, the existing evidence of the residential market points to a significant green premium. An early study by Dian and Miranowski (1989)[4] showed that increasing energy efficiency increases housing prices. Banfi et al. (2005)[1] have published research findings indicating that rental housing tenants are prepared to pay up to 13% higher rent for buildings that have adopted energy-saving measures. Similarly, Fuerst et al (2013)[11] found a price effect of higher energy performance in the British housing market for a large sample of sales transactions in the 1995-2011 time period, indicating a 14% premium of the highest band of the Energy Performance Certificate (EPC) over the lowest band. They also find that this effect tends to be larger for terraced dwellings and flats compared to detached and semi-detached houses. Earlier, Brounen and Kok (2011)[2] had examined the relationship between EPC ratings and sale price for 31,993 residential sale prices in 2008-9 in the Netherlands and report significant premiums for more energy-efficient buildings. Although their dataset contains a large number of control variables, the adoption rate of EPCs in the Dutch housing market was relatively low at the time (7-25% depending on the year) which may limit their findings. Similarly, Zheng and Kahn (2008)[28] and Zheng, Kahn and Deng (2012)[29] find significant price premia for 'green' properties in the Chinese housing market and a study by Deng, Li and Quigley (2012)[3] finds substantial economic returns to green buildings in Singapore. Kok and Kahn (2012)[16] as well as Hyland et al (2013)[13] arrive at similar conclusions for the Californian and the Irish housing market respectively.

This paper examines 'green value' in the Japanese housing market. Using a unique transaction database of contains roughly 50,000 housing transactions in the Tokyo condominium market, we seek to establish whether an eco-label carries a significant premium in asking and/or transaction prices.

There are a number of existing studies on the Japanese market for green buildings, for example Shimizu (2010)[22] (2013) [23] who have conducted an analysis focusing on the new condominium market using asking prices and transaction prices. However, due to the small size of their sales transactions sample, the results did not reach a satisfying level of statistical reliability. A larger study was conducted by Yoshida and Sugiura (2013)[27]. Using a sample of roughly 35,000 condominiums the authors find that eco-labelled condominiums were sold at a discount, rather than a premium and offer a number of empirical and methodological explanations for this result. The present study seeks to clarify the conflicting findings regarding the Tokyo market and contributes to the body of evidence by applying the largest and most comprehensive dataset to date in this investigation of 'green value' in the Japanese context. Crucially, it contains information on the property development company as a proxy for quality as well as buyer characteristics which were possible omitted variables in the earlier studies cited above.

2 Data

The principal source for the sales transactions database applied in this case study is the Tokyo Association of Real Estate Appraisers (2010)[26] which collects transaction prices for new condominiums and used condominiums. Green labels are currently only awarded in the Tokyo market for new builds and not for used condominiums. While our use of new builds only may limit the application of our findings to the general housing market, it avoids the reported problems arising from any discontinuities that may exist in how property characteristics are priced in the new-build and re-sale markets.

The dataset was collected using a survey of house price and attribute information. The most important piece of information concerns prices per unit, both the asking price (which is the producer's offer price) and the recorded transaction price . Further, in order to ensure consistency with the hedonic theory model, data relating to buyer characteristics such as income, household size, etc., was gathered. The questionnaire survey was conducted by the Recruit Housing Institute, starting in November 2011. Surveys were conducted in writing, via submissions from a large number of home buyers. Contract data were also used to collect accurate transaction prices. In addition, information on freehold/leasehold and the form of management were recorded by the questionnaire survey, i.e. is the building managed through visits, (called 'patrols'), through day shifts (a manager works in the administrative office during the day time only), or by having a permanent presence on site (a manager works in the administrative office and is present on a 24-hour basis). The intuition behind gathering this information was that the quality and availability of management services is said to be reflected in condominium prices. More importantly, it can also be viewed as a proxy for other unobservable quality characteristics that might otherwise be captured by the green label which, in the worst case, could lead to omitted variable bias and overstated green premiums. Standard hedonic characteristics such as the total number of condominium units, lot area, and overall building area were also included. Moreover, we assume that price differentials may also arise based on the developer's and (main) construction company's reputation and brand power.[*1]

[*1] A dummy variable was created to distinguish: leading construction companies (1) Takenaka Corporation,

Market conditions and dynamics are an important control variable in any hedonic analysis. Therefore, we included the first-month contract rate as a proxy. The first-month contract rate reflects the percentage of units sold within the first month of marketing a particular property. . It is thought that a higher first-month contract rate reflects better general market conditions but a higher relative rate (i.e. relative to the market average at the time) also indicates how affordable the housing unit prices are in relation to the condominium's features.

In addition to the Recruit Housing Institute's survey data, the Japanese Real Estate Economic Institute's database was used. Along with the developer's asking price, the following key variables were drawn from the Real Estate Economic Institute's database: name of the development company, development overview (development scale), location characteristics (coordinates, address, nearest station, distance to nearest station), and building characteristics (building area, land area, building structure). This information was matched to the data gathered by the Recruit Housing Institute. Appendix 2 contains a complete overview of the variables used in the analysis. Using these sources, a large database was assembled for the 10-year period from 2001 to 2011.

With regard to markers of 'green buildings', data for labelling based on Tokyo Metropolitan Government's Green Labelling System for Condominiums were used. This is based on the Green Building Program which was introduced in June 2002 and mandates that all large-scale construction or major refurbishment projects exceeding 10,000m^2 submit an environmental plan at the time of planning as well as a completion notice. Additionally, in October 2005, the Green Labelling System for Condominiums was started which required the gathering and publishing of information based on four environmental evaluation items. The four evaluation items are: a) quality of building insulation which addresses reduction in the building's heat load; b) facility energy-saving performance, which addresses energy-saving systems; and c) lifespan extension and d) greening of the building, which address lifespan extension, etc., and greening. The evaluation results for the respective items are expressed as a number of star symbols ranging from one to three stars. In addition, in order to increase recognition among consumers, condominium buildings under the obligation to submit an environmental plan document had to indicate the scores of the evaluation items. Moreover, from January 2010 onward, the system was changed to cover not only owner-occupied condominium buildings but also rental condominium buildings and the floor space for which notification is required was lowered to 5,000m^2 in total. This change also stipulated that owners of smaller buildings were also permitted to apply for this label at their own discretion.

The hedonic model used for this analysis includes a dummy variable for buildings with two or more stars for either a) building insulation (covering reduction in the building's heat load) or facility energy-saving performance (covering energy-saving systems) and 0 otherwise. The dummy variable is not applied to buildings which have only one star under the Green Labelling System for Condominiums as this was deemed too low to qualify as a credible 'green' product. Moreover, with regard to building performance evaluation, the existence of a Housing Design Performance Evaluation Document and Housing Construction Performance Evaluation Document based on the Housing Quality Assurance Act is also considered in our analysis. This is done to ensure that the measured price contribution of a green label is separated from the effect of conventional Housing Performance Evaluation and quality assurance documents.

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(2) Obayashi Corporation, (2) Kajima Corporation, (4) Shimizu Corporation, and (5) Taisei Corporation; second-tier construction companies (6) Kumagai Gumi, (7) Toda Corporation, (8) Penta-Ocean Construction, (9) Konoike Construction, (10) Sato Kogyo, (11) Mitsui Construction, (12) Mitsubishi Construction, (13) Sumitomo Construction, (14) Nishimatsu Construction, and (15) Haseko Corporation; and (16) other.

Adequate location controls are essential in any attempt to disentangle the factors contributing to property prices. In the present analysis we use a fine-grained $500m \times 500m$ mesh block in which the condominium is located as a unit. Specifically, the characteristics are built-up area, average floor space, standard deviation of floor space, number of floors for each building and the standard deviation for the number of floors. Next, area-based information on the proportion of the population aged 65 and over and the proportion of office workers in the pertaining census mesh block were added. To account for unobserved spatial characteristics, we also generate a local administrative district dummy. A further set of dummy variables indicates proximity to a railway line and the time required to Tokyo Station from the nearest station was also included as a regressor.

Buyer characteristics are an important feature of our analysis as outlined above. The following variables were considered: home buyers' annual income, age, occupation, household size, number of children and identifier for first time buyers. With regard to occupation , differences by employment status,[*2] work category,[*3] and industry category[*4] were examined.

We first investigate the distributions and descriptive statistics of the underlying dataset. The average asking price has a value of 45.49 million yen, the average value for the actual transaction price was approximately 1.5 million yen lower, at 43.91 million. The floor space ranges from $10m^2$ studio condominiums to large-scale condominiums exceeding $200m^2$. The walking time to the nearest public transit station is 7 minutes on average, while the average time to Tokyo Central Station is 23 minutes which shows that these properties are generally well served by public transportation. Looking at housing buyer characteristics, the average age of buyers was 37 and the average number of people in the household was 2.3, demonstrating that these buyers are typical Japanese households and could hence be considered as representative of Japanese home buyers in general. However, an important caveat is that the household head's average income was 8.51 million, a level that is about twice the Japanese average income.

3 Model specification

Following the overall research strategy outlined in the previous section and taking into account buyer characteristics which are limiting conditions for the bid price function, we specify the following model:

$$P_{(i,j,t)} = f(G_i, X_{(i,j)}, NE_k, HH_{(i,j)})$$

[*2] With regard to employment status, the survey was conducted using the following classification: 01. permanent employee, 02. contract employee, 03. civil servant/public organisation employee, 04. self-employed, 05. physician/lawyer/tax accountant/accountant/etc., 06. part-time/casual, 07. homemaker, 08. student, and 09. unemployed. There were no samples corresponding to contract worker, part-time worker, homemaker, or student.

[*3] The survey was conducted using the following classification for employment category: 01. clerical job, 02. sales job, 03. technical job, 04. service/retail job, 05. construction/manufacturing job, 06. specialized job, 07. management job, and 08. company executive.

[*4] The following items were surveyed as industry categories: 01. agriculture, forestry, and fishing, 02. construction, 03. manufacturing, 04. transportation/warehousing, 05. finance/securities/insurance, 06. advertising/publishing/broadcasting, 07. printing/typesetting, 08. fashion-related, 09. travel/hotel/leisure, 10. restaurant/bar, 11. housing/real estate, 12. trading/wholesaling, 13. retail, 14. software/information services, 15. beauty, 16. medical/welfare, 17. education, 18. creative professions, and 19. other.

$P_{(i,j,t)}$: New condominium price of condominium i and dwelling j at time t (1: asking price, 2: transaction price)
G_i : Green label of condominium i
$X_{(i,j)}$: Building characteristics of condominium i & dwelling j
NE_k : Location characteristics of region k
$HH_{(i,j)}$: Buyer characteristics of condominium i and dwelling j

This specification has a number of desirable properties as compared to previously estimated hedonic functions. Firstly, with regard to the price ($P_{(i,j,t)}$), both the asking and the recorded transaction prices are known in each individual case, allowing us to investigate whether sellers have unrealistically high expectations of the market value of a 'green label'. Secondly, with regard to housing prices, in general, a price differential is generated ($X_{(i,j)}$) based on differences in condominium (i) features such as building structure and the size of the lot area, as well as features related to the dwelling (j), such as the floor space, the unit's position (whether or not it is a corner unit), etc. In terms of the condominium building's features (i), it has increasingly been pointed out that a price differential is generated by the condominium developer or the developer's brand (the developer's reliability and quality assurance, which is difficult to observe visually) and by the construction company. With regard to these variables, developer and construction company information was also gathered and incorporated.

Further to these kinds of building and dwelling characteristics, the characteristics of the surrounding environment, such as the streetscape of the area (k), the commercial density, etc., have a major effect on housing prices. This is known as the neighbourhood effect (NE_k). The neighbourhood effect includes not only the living environment but also the ease of commuting to work or school and the ease of shopping, which are represented by transportation convenience (accessibility of nearest station, time to central business district, etc.).

Moreover, as shown in hedonic theory, it is also to be expected that a price differential will be generated via changes in the bid price function based on buyer characteristics ($HH_{(i,j)}$). The required floor space and housing features change in accordance with the buyer's annual income and household size, and if they are not linear, these characteristics have to be taken into account. In particular, since it is to be expected that factors such as a building's environmental performance will change considerably according to housing buyers' preferences, it may be too much to assume that there is a homogenous utility function (Shimizu, Nishimura, and Karato, 2014[24]).

Based on this kind of model analysis, the following three estimation models were set.
Here, factoring in the time element, the hedonic price function is estimated focusing on the condominium price ($P_{(i,j,t)}$) at time t.
First, as a standard model, the following model was taken as a starting point (Model 1).

$$\log P_{(i,j,t)} = a_0 + a_1 T_{(i,j)} + a_2 G_i + a_3 G_i T_{(i,j)} + \sum_m a_4^m X_{(i,j)}^m + \sum_n a_5^n NE_k^n + \sum_t a_6^t D_t + \varepsilon_{(i,j)} \quad (1)$$

$T_{(i,j)}$ is a transaction dummy (1 in the case of the transaction price; 0 in the case of the asking price), while D_t (t = 2001 to 2011) is a time dummy. With regard to the green label effect (G_i), it is to be expected the degree to which the effect appears will change depending on the asking price (which is the producer's offer price) or the transaction price (which is linked to the bid price). Accordingly, the difference between the two has been incorporated by inserting a cross-term ($G_i \times T_j$) with the transaction price dummy (T_j), which is 1 for the transaction price and 0 for the asking price.

Next, it was expanded into a hedonic function factoring in buyer characteristics, which in theoretical terms should normally be considered, but which were difficult to incorporate into the model due to data limitations (Model 2).

$$\log P_{(i,j,t)} = a_0 + a_1 T_{(i,j)} + a_2 G_i + a_3 G_i T_{(i,j)} + \sum_m a_4^m X_{(i,j)}^m + \sum_n a_5^n NE_k^n + \sum_s a_6^s HH_{(i,j)}^s + \sum_t a_7^t D_t + \varepsilon_{(i,j)} \quad (2)$$

Moreover, how the green label effect (G_i) changed in accordance with the passage of time was analyzed (Model 3).

$$\log P_{(i,j,t)} = a_0 + a_1 T_{(i,j)} + a_2 G_i + a_3 G_i T_{(i,j)} + \sum_m a_4^m X_{(i,j)}^m + \sum_n a_5^n NE_k^n + \sum_s a_6^s HH_{(i,j)}^s + \sum_t a_7^t D_t + \sum_t a_8^t G_i D_t + \varepsilon_{(i,j)} \quad (3)$$

4 Estimation Results

The estimation results for the three models are outlined in Table 1. The baseline estimation (Model 1) reveals that the average asking price for a condominium with a green label (two or three stars out of three) is 6% higher compared to a similar condominium without a label. In other words, the developers of condominiums with superior environmental performance offered them at a marginally but significantly higher price. However, the actual achieved transaction prices are more relevant to our central research hypothesis about the existence of a green premium. The general transaction price variable indicates that transaction prices were on average 3.5% lower than asking prices in the observed period 2001-2011. Green-labelled properties transacted with another marginal discount of 0.9%, with the green transaction price being 4.3% less than the asking price for labelled properties. The total green premium actually observed in the residential sales market therefore reduces to 1.6% (6% − 3.5% − 0.9%). Although relatively small in magnitude, this price premium is statistically significant.

A more detailed list of coefficient estimates is contained in Appendix 1 which reveals a number of additional insights into the pricing of green and non-green condominiums. In cases where a Housing Design *Performance* Evaluation Document (Part A)[*5] exists, condominium prices are marginally higher (0.6%) while the presence of a Housing Performance *Construction* Evaluation Document (Part B) entails a 0.5% premium. These evaluation document variables are important for isolating the 'pure' effect of the green label effect from other types of quality evaluation of newly built properties. Next, similarly distinguishing buildings based on management costs, maintenance/renovation investments, etc., shows that such costs and transaction prices are positive related. Furthermore, the price was lower when the type of land ownership was 'general leasehold' or considerably lower for 'fixed-term leasehold'. The

[*5] The Housing Performance Indication System is based on the Housing Quality Assurance Act that was enacted on April 1, 2000. It evaluates housing performance based on fixed standards, such as complying with the obligatory 10-year defects liability period for basic structural areas of new housing. Under this system, Housing Performance Evaluation Documents are issued, which are divided into Housing Design Performance Evaluation Documents and Housing Construction Performance Evaluation Documents.

price was 2.2% higher when the dwelling is a corner unit. The coefficients of all other control variables including the time-period dummy variables exhibited the expected signs.

Model 2 in Table 1 reports the estimation results using robust regression, an estimation technique which gives proportionally less weight to influential outliers, thereby reducing the potential bias that a small group of properties with extreme or unusual prices and other attributes may introduce to the results. However, the results are only slightly different to the baseline model with a 5.9% asking price premium and a 1.8% transaction price premium for green-labelled properties.

Next, we examine the impact of buyer characteristics on the model (Models 3-6 of Table 1 and Appendix 1). To this aim, we divide buyers' incomes into quartiles and estimate the impact of all price determinants separately for each income quartile. As expected, green asking price premia (as a fraction of the total price) are found to progress with increasing incomes of buyers (from 4% to nearly 8%). Similarly,we find that the average price premium observed in recorded transaction prices (as opposed to asking prices) is mainly driven by households with above-average incomes.paid for green-labelled properties , Given that these are percentages on the total price, a base which is higher for more affluent buyers buying more expensive properties, the spread in terms of absolute monetary values of these price premia is even more pronounced. This finding is significant in that it demonstrates for the first time that 'green' features are more likely to attract higher-income buyers despite arguments to the contrary that claim energy efficiency and the resulting lower utility bills are a larger concern for more income-constrained households.

Further interesting findings (Appendix 1) in terms of buyer characteristics are that first-time buyers exhibit generally a lower willingness to pay, particularly in the lower income segments. This may be taken as an indication of first-time buyers acting more cautiously on the housing market regardless of current income, possibly because of their relatively lower asset possessions compared to buyers who already own a property and seek to 'trade up'. A price differential also occurs based on occupation. Independent of current income and age, it is possible that this variable acts as a proxy for future income or the certainty (stability) of that income. The fact that annual income and employment generate differences in housing prices supports our earlier proposition that prices of both green and non-green properties cannot solely explained by property characteristics but are also a function of socio-economic buyer characteristics.

Table 1. Hedonic regression results

	(1) baseline OLS *lp*	(2) Robust reg *lp*	(3) Income Q1 *lp*	(4) Income Q2 *lp*	(5) Income Q3 *lp*	(6) Income Q4 *lp*
Trans: Transaction price discount	−0.0347***	−0.0316***	−0.0359***	−0.0354***	−0.0337***	−0.0343***
	(−27.87)	(−26.54)	(−11.72)	(−15.94)	(−16.16)	(−13.37)
Green: Green asking price premium[1]	0.0609***	0.0586***	0.0408***	0.0398***	0.0702***	0.0777***
	(18.66)	(18.31)	(3.63)	(6.74)	(13.12)	(12.45)
trgreen: Green transaction price discount[2]	−0.00918*	−0.00948**	−0.0158	−0.00692	−0.00936	−0.00975
	(−2.40)	(−2.59)	(−1.16)	(−1.08)	(−1.50)	(−1.41)
S: Floor Space	0.0243***	0.0244***	0.0160***	0.0143***	0.0135***	0.0146***
	(77.74)	(115.41)	(97.94)	(98.75)	(98.93)	(98.12)
Constant	7.505***	7.508***	7.533***	7.757***	7.861***	7.954***
	(329.53)	(390.22)	(144.48)	(154.72)	(219.17)	(250.75)
Property & condo attributes	Yes	Yes	Yes	Yes	Yes	Yes
Developer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location controls	Yes	Yes	Yes	Yes	Yes	Yes
Management fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Buyer characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	48740	48740	6940	12896	15328	13576
R^2	0.808	0.818	0.799	0.727	0.716	0.783
adj. R^2	0.807	0.818	0.795	0.723	0.714	0.781
AIC	−60598.0	.	−9091.1	−18262.5	−20896.4	−14952.0
BIC	−59296.5	.	−8071.2	−17120.4	−19720.3	−13787.0

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

1: Green asking price premium on equivalent unlabelled condominiums.

2: The dummy variable 'transaction price discount' indicates the average discount observed relative to the equivalent asking price. The dummy variable 'green transaction price discount' indicates the additional discount applied to the transaction of a green-labelled condominium. Both the general transaction price discount and the green transaction price discount have to be subtracted from the green asking price premium to arrive at the green transaction price premium. For example, in Model 1 the total green premium paid in transactions is 1.6% (6% - 3.5% - 0.9%).

Next, we examine how the added economic value of green buildings has changed over time (Table 2). For simplicity, only the estimates for the variables of interest are shown and the results for the large number of control variables are suppressed in this table. First, for the base asking price, the premium rose over time from 5.1% in 2005 to over 7.4% in 2009 but declined considerably in 2010 and 2011. When estimating the transaction discounts relative to asking prices, we find that there were significant discounts from 2008-2011 but no additional effect is found for green transactions. This suggests that the relationship between asking prices and transaction prices was similar for labelled and non-labelled properties when analysed on a year-to-year basis.

Table 2: Hedonic regression results of the 'green premium' over time

Year	*trans*: Transaction discount	*green*: Green asking price premium	*trsgreen*: Green transaction price discount
2005	−0.037	0.051**	−0.046
2006	−0.037	0.044***	−0.001
2007	−0.034	0.066***	0.009
2008	−0.070***	0.063***	0.001
2009	−0.078***	0.074***	0.013
2010	−0.029***	0.040***	0.003
2011	−0.025***	0.0191	−0.015
N	48740		
R^2	0.807		
adj. R^2	0.806		
AIC	−60227.9		
BIC	−58776.8		

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

'Transaction discount' refers to the average discount in transaction prices compared to asking prices in each year. 'Green asking price premium' indicates the average asking price premium of green-labelled condominiums compared to the asking prices for non-labelled condominiums in each year. 'Green transaction price discount' refers to the additional effect of transactions of green-labelled condominiums above and beyond the general 'transaction discount'.

5 Conclusions

This paper set out to test whether obtaining a green label adds value to residential properties in the Japanese housing market using a unique dataset of new condominium transactions in the Tokyo market. Based on our analysis, this question can be answered in much the same way as previous research has done across the world.

The hedonic analysis shows a clear price premium for green-labelled condominiums both in asking and transaction price. Although the effect for the latter is rather small (around 1.7% of the transaction price). Taking into account buyer characteristics (Model 2), we find that wealthier buyers are willing to pay a higher premium for green-labelled properties, both in absolute and in relative terms. It appears that eco-labelled condominiums in Tokyo are a luxury good that is offered primarily to high-income households who are able and willing to pay a premium for owning and occupying a green-labelled property.

In addition, if one looks at temporal changes in the premium, we find that the effect of green labels became larger over time before declining again in the final two years of the study

period. In terms of the possible reasons for this, it may be the case that the awareness of green buildings has increased in the Japanese residential market in the years 2006-2010 and that the buyer segment actively seeking to invest in their value is expanding. Further analysis is required to ascertain whether the absence of the premium in the most recent year (2011) is a continued trend that marks the end of a 'green premium era' or is simply a one-off occurrence.
A number of caveats remain for this analysis. First, one could point out the problem of accuracy with regard to the green labels used as variables in order to distinguish properties with superior environmental performance. The current labelling system is based on applications from developers, and it does no more than indicate buildings' hypothetical environmental performance at the time of development. Buyers may be reluctant to pay significant premia for energy efficiency and cost savings that are not proven in operation.
In addition, unless the added economic value of green buildings offsets or exceeds the added development costs, developers are unlikely to develop many green buildings unless they receive subsidies to make up for the shortfall. It is possible that the premium we measured may still be too low in comparison to the added development expenses which may be an obstacle to more widespread adaptation of green buildings in the Japanese market.
Furthermore, it is also uncertain how the green building submarket will be embedded in the broader housing market that comprises mainly existing stock. Under the current system, green labels only cover newly developed buildings, but for green building policies to be more effective the application of labels to existing stocks will have to be considered. Notably, when it comes to a buyer's choice of home, the decision is typically made under considerable budget restrictions. With the rapid changes in Japanese demographic structure, the population of people in their 30s and 40s – which is the home-buyer segment that generates the greatest demand for housing – is decreasing significantly. In this context, it will be necessary to keep monitoring whether there continues to be an added value and price premiums for green buildings. Finally, the economic value of green buildings will also be impacted upon by more stringent environmental regulations are implemented in future (Takagi and Shimizu, 2010[25]) but it is difficult to foresee how Japanese eco labels for buildings will adopt to these changing market conditions.

References

[1] 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.

[2] Brounen, D. and Kok, N. (2011) On the Economics of Energy Labels in the Housing Market, *Journal of Environmental Economics and Management*, 62, pp. 166-179.

[3] Deng, Y., Li, Z., & Quigley, J. M. (2012). Economic returns to energy-efficient investments in the housing market: evidence from Singapore. *Regional Science and Urban Economics*, 42(3), 506-515.

[4] 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*, 25, pp. 52-67.

[5] Eichholtz, P; Quigley, J. (2012): Green building finance and investments: Practice, policy and research. *European Economic Review* 56.5 (2012): 903-904.

[6] Eichholtz, P, Kok, N and Quigley, J. 2010 Doing Well By Doing Good? Green Office Buildings, *American Economic Review* 100 2492-2509.

[7] Eichholtz, P. Kok, N. and Quigley, J. 2011 The economics of green building. *Review of Economics and Statistics*, in press.

[8] Ekeland, I., J. J. Heckman and L. Nesheim, (2004), Identification and Estimation of Hedonic Models, *Journal of Political Economy*, 112, pp.60-109.

[9] Fuerst, F. and McAllister, P. (2011) Eco-Labelling in Commercial Office Markets: Do LEED and Energy Star Offices Obtain Multiple Premiums? *Ecological Economics*, 70, pp. 1220-1230.

[10] Fuerst,F.,and P. McAllister(2010), Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values, *Real Estate Economics*, 39, pp. 45–69.

[11] Fuerst, F.; McAllister, P.; Nanda, A.; Wyatt, P. (2013): An investigation of the effect of EPC ratings on house prices. Department of Energy and Climate Change, Report, 17 June 2013.

[12] Reichardt, A.; Fuerst, F.; Rottke, N.; Zietz, J. (2012): Sustainable Building Certification and the Rent Premium: A Panel Data Approach. *Journal of Real Estate Research*. 34/1, 99-126.

[13] Hyland, M., Lyons, R. C., & Lyons, S. (2013). The value of domestic building energy efficiency—evidence from Ireland. *Energy Economics*, 40, 943-952.

[14] Jacobsen, G. D., Kotchen, M. J., & Vandenbergh, M. P. (2012). The behavioral response to voluntary provision of an environmental public good: Evidence from residential electricity demand. *European Economic Review*, 56(5), 946-960.

[15] Kotchen, M. J. (2006). Green markets and private provision of public goods. *Journal of Political Economy*, 114(4), 816-834.

[16] Kok, N., Kahn M.E. (2012) The value of green labels in the Californian housing market. Working paper.

[17] Miller, N, Spivey, J. & Florance, A. (2008). Does Green Pay Off? *Journal of Real Estate Portfolio Management*, 14, 385-399.

[18] Ministry of Land, Infrastructure, Transport, and Tourism Land and Water Bureau (2010), Conference on the Green Value of Buildings Research Report, Ministry of Land, Infrastructure, Transport, and Tourism.

[19] Reichardt, A. Fuerst, F. Rottke, N. and Zietz, J. 2011 The business case of sustainable building certification: A panel data approach. *Journal of Real Estate Research*, 34, 99-126.

[20] Requate, T., Unold, W., 2003. Environmental policy incentives to adopt advanced abatement technology: will the true ranking please stand up? *European Economic Review* 47, 125-146.

[21] Rosen, S., (1974), Hedonic Prices and Implicit Markets, Product Differentiation in Pure Competition, *Journal of Political Economy*, 82, pp.34-55.

[22] Shimizu, C. (2010), Will green buildings be appropriately valued by the market?,*RIPESS* (*Reitaku Institute of Political Economics and Social Studies*) *Working Paper*,No.40.

[23] Shimizu, C (2013), "Sustainable Measures and Economic Value in Green Housing," *Open House International Journal*, Vol.38,No.3,pp57-63.

[24] Shimizu, C., K.G.Nishimura, and K.Karato, (2014), Nonlinearity of Housing Price Structure: the Secondhand Condominium Market in the Tokyo Metropolitan Area, *International Journal of Housing Markets and Analysis*, Vol.4, issue 4.(forthcoming).

[25] Takagi,Y and C.Shimizu.(2010), The Environment and Real-Estate Investment:Responsible property investing,*Business Ethics and Compliance Research Center Working Paper(Reitaku University)*,No.6.

[26] Tokyo Association of Real Estate Appraisers (2010), Property environmental friendliness and asset prices: Empirical evidence based on Tokyo condominiums.

[27] Yoshida, J., & Sugiura, A. (2013). The Effects of Multiple Green Factors on Condominium Prices. *The Journal of Real Estate Finance and Economics*, 1-26.(published online, April 2014).

[28] Zheng, S., Wu, J., Kahn, M (2008):. Land and residential property markets in a booming economy: new evidence from Beijing. Journal of Urban Economics 63:743-757.

[29] Zheng, S., Wu, J., Kahn, M. E., & Deng, Y. (2012). The nascent market for "green" real estate in Beijing. *European Economic Review*, 56(5), 974-984.

Appendix

Table A1. Full regression results of Tokyo case study

	(1) baseline OLS *lp*	(2) Robust reg *lp*	(3) Income Q1 *lp*	(4) Income Q2 *lp*	(5) Income Q3 *lp*	(6) Income Q4 *lp*	(7) Time effects *lp*
trans	−0.0347***	−0.0316***	−0.0359***	−0.0354***	−0.0337***	−0.0343***	−0.0347***
	(−27.87)	(−26.54)	(−11.72)	(−15.94)	(−16.16)	(−13.37)	(−27.40)
green	0.0609***	0.0586***	0.0408***	0.0398***	0.0702***	0.0777***	0.0644***
	(18.66)	(18.31)	(3.63)	(6.74)	(13.12)	(12.45)	(19.43)
trgreen	−0.00918*	−0.00948**	−0.0158	−0.00692	−0.00936	−0.00975	−0.00918*
	(−2.40)	(−2.59)	(−1.16)	(−1.08)	(−1.50)	(−1.41)	(−2.37)
S	0.0243***	0.0244***	0.0160***	0.0143***	0.0135***	0.0146***	0.0155***
	(77.74)	(115.41)	(97.94)	(98.75)	(98.93)	(98.12)	(233.33)
S squared	−0.0000632***	−0.0000649***					
	(−27.92)	(−43.89)					
ts	−0.00962***	−0.00937***	−0.00867***	−0.00827***	−0.00735***	−0.0101***	−0.00934***
	(−51.06)	(−54.42)	(−19.56)	(−24.63)	(−22.17)	(−23.97)	(−48.92)
bus	−0.0358***	−0.0386***	−0.0283***	−0.0172**	−0.0468***	−0.0578***	−0.0366***
	(−9.59)	(−11.24)	(−3.67)	(−3.05)	(−6.34)	(−5.84)	(−9.47)
busTS	−0.00182***	−0.00214***	−0.000897	−0.00225***	−0.00156*	−0.00486***	−0.00213***
	(−5.27)	(−6.87)	(−1.35)	(−4.27)	(−2.39)	(−4.50)	(−5.94)
TA	−7.83*e*-09	2.61*e*-08	−0.000000128	3.36*e*-08	0.000000185***	−0.000000167***	−2.75*e*-08
	(−0.32)	(1.21)	(−1.64)	(0.69)	(4.30)	(−3.83)	(−1.10)
ISP1	0.00679**	0.00689**	0.0109	0.00316	0.00387	0.00272	0.00687**
	(2.89)	(3.17)	(1.66)	(0.71)	(1.03)	(0.60)	(2.89)
ISP2	0.00486**	0.00321	0.0104*	0.00842*	0.000887	−0.00413	0.00371
	(2.60)	(1.89)	(2.06)	(2.55)	(0.28)	(−1.13)	(1.96)

MG1	0.00126	0.000758	−0.00673	0.00158	0.00206	0.00412	0.00253
	(0.67)	(0.42)	(−1.46)	(0.50)	(0.62)	(1.02)	(1.33)
MG2	0.0238***	0.0232***	0.0247***	0.0239***	0.0204***	0.0158**	0.0265***
	(9.09)	(9.80)	(3.30)	(5.09)	(4.63)	(3.13)	(9.94)
RL1	−0.00909***	−0.00805***	−0.00000228	−0.00490	−0.00573	−0.00999**	−0.00928***
	(−5.02)	(−4.68)	(−0.00)	(−1.44)	(−1.95)	(−2.63)	(−5.08)
RL2	−0.0402***	−0.0449***	−0.0285	−0.0432**	−0.0355**	0.00643	−0.0386***
	(−4.62)	(−5.76)	(−1.64)	(−3.09)	(−2.60)	(0.23)	(−4.54)
corner	0.0213***	0.0216***	0.0280***	0.0188***	0.0162***	0.00959***	0.0178***
	(15.59)	(16.46)	(7.92)	(7.61)	(6.90)	(3.55)	(12.81)
structure	−0.00894	−0.0117*	0.0233	0.00594	−0.0283***	−0.0279***	−0.0113*
	(−1.71)	(−2.42)	(1.92)	(0.49)	(−3.69)	(−3.90)	(−2.15)
TR	−0.000152***	−0.000141***	−0.000173**	−0.000253***	−0.0000641	−0.0000874	−0.000133***
	(−5.58)	(−5.17)	(−2.74)	(−5.36)	(−1.30)	(−1.41)	(−4.79)
tt	−0.00190***	−0.00197***	−0.00213***	−0.00169***	−0.00154***	−0.00111***	−0.00178***
	(−15.91)	(−18.90)	(−7.38)	(−7.93)	(−7.82)	(−4.62)	(−14.91)
FAR	−0.0000116	−0.00000557	−0.0000318	−0.0000109	−0.0000224	0.00000324	−0.0000114
	(−1.63)	(−0.93)	(−1.73)	(−0.82)	(−1.72)	(0.25)	(−1.58)
comm	0.0143***	0.0146***	0.0225***	0.0103*	0.0129***	0.00580	0.0126***
	(6.68)	(7.45)	(4.34)	(2.47)	(3.50)	(1.37)	(5.81)
indust	−0.0330***	−0.0317***	−0.0314***	−0.0217***	−0.0253***	−0.0388***	−0.0319***
	(−17.70)	(−18.40)	(−6.12)	(−7.22)	(−8.11)	(−9.22)	(−16.98)
rental	−0.0000486***	−0.0000455***	−0.0000251***	−0.0000450***	−0.0000406***	−0.0000646***	−0.0000485***
	(−17.94)	(−17.23)	(−3.42)	(−8.97)	(−8.91)	(−11.56)	(−17.51)
old	−0.0000223***	−0.0000230***	−0.0000263*	−0.0000172*	−0.00000433	0.00000189	−0.0000173***
	(−5.28)	(−5.55)	(−2.51)	(−2.25)	(−0.61)	(0.20)	(−4.03)
strc2	0.0165**	0.0135**	0.0324**	0.0213	−0.00330	0.00733	0.0138**
	(3.15)	(2.76)	(2.59)	(1.75)	(−0.43)	(1.00)	(2.59)
officew	0.000296***	0.000293***	0.000198***	0.000316***	0.000268***	0.000255***	0.000295***
	(28.51)	(30.47)	(7.27)	(16.06)	(15.27)	(12.16)	(27.97)

cost	0.00589***	0.00528***	0.00320*	0.00342***	0.00501***	0.00713***	0.00575***
	(11.07)	(11.24)	(2.53)	(3.64)	(6.19)	(6.12)	(10.61)
year4	−0.0145***	−0.0135***	−0.0221***	−0.0174***	−0.0132***	−0.0175***	−0.0152***
	(−6.89)	(−6.28)	(−4.01)	(−4.37)	(−3.74)	(−3.89)	(−7.06)
year5	−0.0232***	−0.0211***	−0.0301***	−0.0261***	−0.0186***	−0.0348***	−0.0291***
	(−10.02)	(−9.38)	(−5.22)	(−6.13)	(−4.60)	(−7.01)	(−12.39)
year6	−0.00897***	−0.00816**	−0.00377	−0.0140**	−0.0127**	−0.00387	−0.0149***
	(−3.32)	(−3.13)	(−0.58)	(−2.93)	(−2.74)	(−0.66)	(−5.45)
year7	−0.0218***	−0.0200***	−0.0128	−0.0233***	−0.0221***	−0.0112	−0.0264***
	(−7.48)	(−7.24)	(−1.81)	(−4.50)	(−4.37)	(−1.72)	(−8.89)
year8	0.00652*	0.00565	0.0216**	0.0116*	0.00608	0.0159*	0.00507
	(2.08)	(1.90)	(2.85)	(2.00)	(1.14)	(2.39)	(1.60)
year9	0.0535***	0.0574***	0.0712***	0.0681***	0.0485***	0.0448***	0.0503***
	(16.18)	(18.92)	(8.75)	(12.09)	(8.13)	(6.39)	(15.03)
year10	0.155***	0.158***	0.0964***	0.145***	0.143***	0.163***	0.150***
	(39.14)	(44.08)	(8.57)	(20.23)	(21.17)	(21.95)	(37.78)
year11	0.180***	0.191***	0.189***	0.164***	0.163***	0.177***	0.173***
	(37.02)	(49.13)	(13.46)	(18.51)	(19.15)	(19.20)	(35.52)
year12	0.156***	0.158***	0.137***	0.147***	0.140***	0.155***	0.149***
	(38.84)	(42.17)	(11.38)	(20.18)	(20.63)	(18.86)	(36.28)
year13	0.162***	0.164***	0.156***	0.147***	0.141***	0.155***	0.155***
	(48.56)	(51.80)	(16.35)	(22.47)	(24.56)	(23.59)	(45.17)
year14	0.163***	0.164***	0.147***	0.153***	0.157***	0.177***	0.161***
	(46.76)	(46.54)	(15.09)	(24.26)	(25.89)	(24.35)	(45.23)
age			0.000695***	0.000736***	0.000222	0.00000781	
			(4.38)	(4.18)	(1.36)	(0.04)	
number			−0.00526**	−0.00448***	−0.00262*	−0.00343*	
			(−2.81)	(−3.50)	(−2.20)	(−2.30)	
childdummy			−0.00517	−0.00110	−0.00230	0.00536	
			(−1.45)	(−0.42)	(−0.90)	(1.70)	

first			−0.0359***	−0.0148***	0.000582	−0.00675*	
			(−6.88)	(−3.67)	(0.18)	(−2.32)	
invest			0.0557*	−0.0832*	−0.153***	−0.117***	
			(2.07)	(−2.27)	(−4.55)	(−6.35)	
hd4			0.00526	0.0160**	0.00752	−0.00105	
			(0.81)	(3.27)	(1.95)	(−0.24)	
hd6			0.0716***	0.00667	0.0423***	0.0467***	
			(4.93)	(0.43)	(4.93)	(6.88)	
wd7			0.0151**	−0.00113	0.00143	0.0146***	
			(2.97)	(−0.33)	(0.38)	(3.67)	
wd8			0.0133	0.00295	0.00827*	0.00779*	
			(1.57)	(0.57)	(2.41)	(2.53)	
wd9			0.0369**	0.00849	0.0190*	0.0183**	
			(2.87)	(0.79)	(2.36)	(3.00)	
yd6			0.00666	−0.00442	0.00767*	0.00850**	
			(0.92)	(−0.77)	(2.37)	(2.76)	
_cons	7.505***	7.508***	7.533***	7.757***	7.861***	7.954***	7.788***
	(329.53)	(390.22)	(144.48)	(154.72)	(219.17)	(250.75)	(368.49)
N	48740	48740	6940	12896	15328	13576	48740
R^2	0.808	0.818	0.799	0.727	0.716	0.783	0.801
adj. R^2	0.807	0.818	0.795	0.723	0.714	0.781	0.801
AIC	−60598.0	.	−9091.1	−18262.5	−20896.4	−14952.0	−58949.5
BIC	−59296.5	.	−8071.2	−17120.4	−19720.3	−13787.0	−57656.7

Table A2. Variable names and data sources for Tokyo case study

Symbol	Variable	Content	Unit	Source
$green$	Green label dummy	Green building = 1 Other building = 0	$(0, 1)$	Tokyo Metropolitan Government
$trans$	Transaction price dummy	Transaction price = 1 Asking price = 0	$(0, 1)$	RECRUIT
S	Floor space	Floor space of building /square meters	m^2	Real Estate Economic Institute
TS	Distance to the nearest station	Distance to the nearest station.	m	Real Estate Economic Institute
Bus	Bus dummy	bus-transportation area = 1 walk-transportation area = 0	$(0, 1)$	Real Estate Economic Institute
TT	Time to CBD(Tokyo station)	Average travel time from the nearest rail transit station to Tokyo Central Station during daytime hours	min.	VAL Institute
TU	Total unit	Total units of condominium	unit	Real Estate Economic Institute
$Land$	Site area	Site area of condominium	m^2	Real Estate Economic Institute
TA	Total building area	Total building area of condominium	m^2	Real Estate Economic Institute
$Cost$	Management Cost	Property Management Cost	¥$10K$ /mo.	RECRUIT
$ISP1$	With Housing performance evaluation report A dummy	With Housing performance evaluation report A = 1 Without Housing performance evaluation report A = 0	$(0, 1)$	RECRUIT
$ISP2$	With Housing performance evaluation report B dummy	With Housing performance evaluation report B = 1 Without Housing performance evaluation report B = 0	$(0, 1)$	RECRUIT

Symbol	Variable	Content	Unit	Source
$MG1$	Management type(A) dummy	Management typ is A = 1 other = 0	$(0,1)$	RECRUIT
$MG2$	Management type(B) dummy	Management typ is B = 1 other = 0	$(0,1)$	RECRUIT
$Corner$	corner dummy	The location of unit is corner = 1 Other location = 0	$(0,1)$	Real Estate Economic Institute
STD	Studio type dummy	Floor space $30m^2$ or less = 1 Floor space over $30m^2$ = 0	$(0,1)$	Real Estate Economic Institute
$RL1$	Leasehold(A) dummy	Land right is leasehold (Type A) = 1 other = 0	$(0,1)$	RECRUIT
$RL2$	Leasehold(B) dummy	Land right is leasehold (Type B) = 1 other = 0	$(0,1)$	RECRUIT
TR	Rate of Sales	Rate of sales in first month	%	Real Estate Economic Institute
LU_g $(g = 0, \ldots, G)$	Land Use regulation dummy	g-th Land use regulation area = 1 other = 0, (residential, office, industrial)	$(0,1)$	Real Estate Economic Institute
HD_h $(h = 0, \ldots, H)$	Employment status dummy	h-th Employment status of Head of household = 1, other = 0	$(0,1)$	RECRUIT
WD_i $(i = 0, \ldots, I)$	Job type dummy	i-th job type = 1, other = 0	$(0,1)$	RECRUIT
YD_j $(j = 0, \ldots, J)$	Business type dummy	j-th business type = 1, other = 0	$(0,1)$	RECRUIT
LD_k $(k = 0, \ldots, K)$	Location (ward) dummy	k-th administrative district = 1, Other district = 0.	$(0,1)$	Real Estate Economic Institute
RD_l $(l = 0, \ldots, L)$	Railway line dummy	l-th railway line = 1 Other railway line = 0.	$(0,1)$	Real Estate Economic Institute
D_m $(m = 0, \ldots, M)$	Time dummy (yearly)	m-th year = 1 Other year = 0.	$(0,1)$	RECRUIT