Cambridge University Land Society

ALUMNI

# CULS Working Paper Series

**No. 01 (2015)**

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


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***Abstract***

*Using a unique transaction database of condominiums in the Tokyo metropolitan area and a hedonic analytical framework, we find that eco-labelled buildings command a small but significant premium on both the asking and transaction prices. This finding is consistent with results from other countries but in contrast to these studies, the present analysis also incorporates buyer characteristics which provide further information on the sources of demand for eco-labelled real estate. A separate estimation by subgroups reveals that the price premium is primarily driven by wealthier 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. Less affluent households are also shown to pay higher prices for the eco label but the effect is less pronounced. The results indicate that capitalised utility bill savings are likely to account for a large proportion of the observed premium but the higher premium paid by affluent households suggests that more intangible benefits of living in a green building may also play a role.*

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Research into the profitability of environmentally friendly buildings has reached a critical juncture. The seminal studies (Miller, Spivey, Florance, 2008, Fuerst and McAllister, 2011, Reichardt, Fuerst and Zietz, 2012, Eichholtz, Kok and Quigley, 2010, 2011 and Eichholtz and Quigley 2012 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 property markets in specific countries and over specific time frames 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 relatively 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.

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' of real estate investments 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 widely accepted proposition that monetary incentives are more effective in reducing environmental harm than ‘command and control’ policies, (Requate and Unold (2003)), the housing market seems to be lagging behind other sectors in offering an attractive business case for investments in sustainability and energy efficiency. 'Green' financial instruments are still not used widely in the residential sector which makes capitalisation into the lump-sum house price the only channel for economic rewards of sustainability. 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), 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 aggregate 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 et al (2012).in the context of residential electricity demand. However, it may be argued that the privatised public good is a at best a secondary consideration of green consumers whose decision may be guided by purely private cost savings in the form of lower utility bills and, equally private, green signalling benefits to their social peers, costumers etc. It seems likely that any observed green premium primarily reflects these private benefits.

Despite these apparent obstacles, the existing evidence on housing markets points to a significant green premium. An early study by Dian and Miranowski (1989) showed that investments in energy efficiency increase house prices. Banfi et al. (2005) published research findings indicating that residential tenants are prepared to pay up to 13% higher rent for buildings that have adopted energy-saving measures. Similarly, Fuerst et al (2015) 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) 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) and Zheng, Kahn and Deng (2012) find significant price premia for 'green' properties in the Chinese housing market and a study by Deng, Li and Quigley (2012) finds substantial economic returns to green buildings in Singapore. Kok and Kahn (2014) as well as Hyland et al (2013) arrive at similar conclusions for the Californian and the Irish housing market respectively.

This paper examines the 'green value' proposition in the context of the Japanese housing market. Using a unique transaction database of contains roughly 25,000 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) 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 (2015). 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. A possible reason is that Japan is already characterised by a high level of energy efficiency in the building and appliances sector as well as the larger economy which may be why a green label carries less currency compared to a market with lower average levels of energy efficiency where considerable savings can be expected from a green product. Interestingly, however, they do find a premium for long-life design, suggesting a willingness to pay for superior durability and slower depreciation of a building or condominium. [1]

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

1This interpretation of the private provision of public goods hypothesis in the light of the current study of the Tokyo green housing label was provided by an anonymous reviewer of this paper whom we thank.

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.

***Data***

The principal source for the sales transactions database applied in this case study is the Tokyo Association of Real Estate Appraisers (2010) 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 hedonic theory, 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..[2]

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2A dummy variable was created to distinguish: leading construction companies (1) Takenaka Corporation, (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

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 (geo-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 1 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 but the 2001-2003 period is disregarded in our analysis as no transactions of eco-labelled buildings were recorded during that time.

We identify green buildings as those that are labelled under the Tokyo Metropolitan Government's Green Labelling System for Condominiums. This scheme 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-

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Construction, (14) Nishimatsu Construction, and (15) Haseko Corporation; and (16) other.

occupied condominium buildings but also rental condominium buildings and the floor space for which notification is required was lowered to 5,000 $m^2$ 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.

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 x 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,[3] work category,[4] and industry category[5] were

[3] Regarding employment status, the survey uses 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.

[4] 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.

examined.

In a preliminary step, the distributions and descriptive statistics of the underlying dataset are investigated (Table 1). The average asking price of a condominium in Tokyo in the 2005-11 period was 45.49 million yen while the average value for the transaction price was approximately 1.5 million yen lower, at 43.91 million. Large variations in size are oberved, 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 the properties in our sample are generally well served by public transportation and are hence comparable with regard to location value. Looking at 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.

*Table 1: Summary statistics of the estimation sample*

| | average | standard deviation | minimum | maximum |
|---|---|---|---|---|
| asking price (¥ 10,000) | 4,589.10 | 1,470.73 | 1,190.00 | 20,600.00 |
| transaction price (¥ 10,000) | 4,425.59 | 1,395.83 | 276.00 | 18,567.00 |
| floor space (sq.m.) | 70.40 | 14.60 | 20.37 | 201.34 |
| time to nearest station (min) | 7.57 | 4.21 | 1.00 | 36.00 |
| time to Tokyo Central (min) | 23.03 | 10.71 | 0.00 | 175.00 |
| Age of household head (yr) | 37.39 | 8.81 | 20.00 | 90.00 |
| Household size (persons) | 2.36 | 1.05 | 1.00 | 20.00 |
| Household income (¥10,000) | 857.11 | 426.53 | 0.00 | 3,000.00 |
| Total units of project | 222.90 | 346.17 | 9.00 | 2,801.00 |
| Site area (sq.m.) | 5,607.56 | 7,577.62 | 138.55 | 48,303.23 |
| Total building area (sq.m.) | 22,741.43 | 45,568.15 | 229.97 | 383,340.30 |

management job, and 08. company executive.

[5] 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.

Number of observations=23,920

***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:

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

$P_{(i,j,t)}$ : 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, regarding the definition of 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, 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. Therefore, developer and construction company information was also gathered and incorporated into our analysis.

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 house prices, proxied by a neighbourhood effect ( $NE_k$ ) in our estimation. Accessibility to jobs, schools, shopping and other routine destinations are captured by variables measuring the distance to the nearest station, travel time to central business district, etc.

Moreover, hedonic pricing theory predicts that the addition of buyer characteristics will yield different bid curves reflecting different utility functions and budget constraints. For example, the marginal utility of an extra unit of space will be higher for larger households, all else equal. Model 3 relaxes the assumption of a homogenous utility function of all buyers by controlling for a series of buyer characteristics in line with suggestions made in the extant literature (see Shimizu, Nishimura, and Karato, 2007).

Based on these considerations, 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 is taken as a starting point (Model 1).

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

where $T_{(i,j)}$ is a transaction dummy (1 in the case of the transaction price; 0 in the case of the asking price), while $D_t$ (*t* = 2004 to 2011) is a time dummy. The green label effect is captured by a binary variable ( $G_i$ ). The difference between green asking and transaction prices can then be derived from a cross-term ( $G_i \times T_j$ ). 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).

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

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

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

Regarding appropriate estimation techniques, our baseline model is an Ordinary Least Squares (OLS) model in line with the Gauss-Markov Theorem which states that OLS will yield the best linear unbiased estimator provided that the usual assumptions are met. Efficiency as well as ease of computation and interpretation make OLS the method of choice for the majority of hedonic pricing studies. However, since OLS is known to be sensitive to outliers, we also use robust regression as an alternative estimation technique to see whether this changes the results for the variables of interest. In particular, Cook's distance measures are used to identify bad leverage outliers and Huber and Tukey biweights are applied to offset the distorting influence of these outliers on the regression parameters as suggested by Huber, 1964; Rousseeuw and Leroy, 1987 and Verardi and Croux, 2009. Using OLS and robust regression in tandem should provide us with a stable estimate of any pricing differentials related to the Tokyo Green Label.

### *Estimation Results and Discussion*

The estimation results for the three models are outlined in Table 2 (full estimation results in Appendix 2). The baseline estimation (Model 1) reveals that the average asking price for a condominium with a green label is roughly 5% 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 main research hypothesis about the existence of a green premium in the Tokyo housing market. The general transaction price variable indicates that transaction prices were on average approximately 4% lower than asking prices in the observed period 2004-2011. When we test specifically how transaction prices of green labelled buildings differ from their average asking prices, the coefficients are not statistically significant at the 5 percent level. This finding suggests that the value of the green label was not significantly overestimated by sellers relative to the implicit valuation of the buyers. A more detailed list of coefficient estimates is contained in Appendix 2 which reveals a number of additional insights into the pricing of green and non-green condominiums. Both the Housing Design *Performance* Evaluation Document (Part A)[6] and the Housing Performance *Construction* Evaluation Document (Part B) attract marginal but significant price premiums. 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 price was 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 2 reports the estimation results using robust regression, an estimation technique which gives proportionally less weight to influential outliers as described in the previous section, 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 4.3% asking price premium and a negligible and insignificant transaction price premium for green-labelled properties.

Next, we examine the impact of buyer characteristics on the model (Models 3-7 of Table 2). To this aim, we divide buyers' incomes into four groups and estimate the impact of all price determinants separately for each income group[7]. 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.

[6] The Housing Performance Indication System is based on the Housing Quality Assurance Act 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.

[7] Income groups are defined on a per capita basis of household members as follows: lower income: up to ￥2.5million p.a. (n=6,038), medium low income:￥2.51 -4.00 million (n=6,982), medium high income:￥4.01 - 5.50 million (n=6,012), high income:￥5.50 million (n=4,568)

Further findings relating to buyer characteristics are that first-time buyers exhibit generally a lower willingness or ability to pay, particularly in the lower income segments (Appendix 2). 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 of that income. The fact that annual income and employment generate differences in house 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.

An important caveat to these findings is that the coefficient estimates of the green asking and transaction price premiums as reported here may overestimate the 'true' magnitude of the premium for several reasons. Firstly, the green label may be correlated with unobserved quality characteristics of the condominiums which may then get lumped into the green premium estimate. While we cannot rule out completely that such an estimation problem exists, reassurance is provided by the large numbers of hedonic building, spatial and socio-economic characteristics used in the estimation which go far beyond the standard set of variables used in the hedonic estimation. The high goodness of fit of the models around 80% of explained variance is testimony to the quality of the dataset.

A second concern is that the positive relationship between household income and observed green price premiums may simply reflect better access to capital for more affluent households. In other words, it is possible that the underlying willingness to pay is independent of income and wealth but only high-income households have access to the additional debt or equity capital required to buy a green-labelled condominium. This point is important as it may undermine the concept of the green label as an upmarket luxury good. More specifically, if the premium were merely a capitalisation of the discounted future utility cost reduction and possibly favourable government treatment of green-labelled condominium schemes, the different premia obtained for the household income groups may simply show the progression of incomplete capitalisation for low incomes to complete capitalisation of these cost savings for high incomes. To test this concern empirically we would require data on actual energy consumption along with a vector of control variables to measure the true cost savings associated with Tokyo Green Label condominiums in operation. In the absence of such data, we can only provide rough estimates derived from the existing literature. Adan and Fuerst (2016) report a reduction of 3 to 13 % in energy consumption of housing in the UK following a range of heating system and insulation related green retrofit measures. An earlier study by Hong et al (2006) reports a reduction in heating demand by 10% in centrally heated and 17% in non-centrally heated properties. Considering that utility costs are only a relatively small fraction of the capital value of a house or condominium, it thus seems likely that the average premium of approximately 5% on average for the Tokyo market reflects more than mere utility cost savings. An example using statistics on average energy consumption levels can illustrate this point. According to the Family Income and Expenditure Survey compiled by the Japanese Ministry of Internal Affairs and Communication, the average household gas bill (Tokyo Gas) amounts to￥4,972 and the electricity bill to ￥9,472. Assuming that households consume 20% less gas and electricity in green-labelled buildings, the equivalent figures for households in these buildings would be ￥7,577 and electricity to ￥3,977. The nominal undiscounted combined savings would then amount to ￥866,640 (USD 7,100) over a 25 year period. Given an average transaction price of ￥44.25 million per condominium in our database, this would amount to only 2 percent of the property value and is hence considerably lower than the estimated total premium of approximately 5 percent. Conversely, households would have to achieve reductions in their energy consumption by more than 50% compared to households in the non-green building peer group to justify the measured green price premium. If the nominal undiscounted savings in our approximation were to be calculated to the net present value, the required energy savings of the green label would need to be even higher. It hence seems likely that the green premium reflects more than just the pure capitalisation of cost savings.

*Table 2: Hedonic regression results (dependent variable: log price)*

| | (1)<br>Baseline OLS | (2)<br>Robust reg | (3)<br>OLS with HH char | (4)<br>OLS: Income low | (5)<br>OLS: Income medium low | (6)<br>OLS: Income medium high | (7)<br>OLS: Income high |
|---|---|---|---|---|---|---|---|
| **Green asking price premium[1]** | **0.0482*** ** | **0.0428*** ** | **0.0475*** ** | **0.0368*** ** | **0.0389*** ** | **0.0511*** ** | **0.0589*** ** |
| | **(14.43)** | **(13.00)** | **(14.38)** | **(6.00)** | **(6.82)** | **(7.82)** | **(7.13)** |
| **Green transaction price discount[2]** | **-0.00552** | **-0.00592** | **-0.00552** | **-0.00111** | **-0.000849** | **-0.00888** | **-0.0132** |
| | **(-1.44)** | **(-1.58)** | **(-1.46)** | **(-0.17)** | **(-0.14)** | **(-1.21)** | **(-1.36)** |
| Transaction price discount | -0.0383*** | -0.0351*** | -0.0383*** | -0.0435*** | -0.0417*** | -0.0336*** | -0.0330*** |
| | (-19.93) | (-20.20) | (-20.13) | (-12.88) | (-12.09) | (-9.66) | (-7.31) |
| *Property & condo attributes* | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Developer fixed effects* | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Location controls* | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Management fixed effects* | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *Buyer characteristics* | No | No | Yes | Yes | Yes | Yes | Yes |
| *Time fixed effects* | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 23,922 | 23,922 | 23,922 | 6,038 | 6,982 | 6,012 | 4,568 |
| $R^2$ | 0.810 | 0.829 | 0.814 | 0.793 | 0.803 | 0.846 | 0.855 |
| adj. $R^2$ | 0.809 | 0.828 | 0.813 | 0.788 | 0.799 | 0.842 | 0.850 |
| *AIC* | -29921.2 | . | -30403.8 | -8982.8 | -9474.5 | -8421.7 | -5171.7 |
| *BIC* | -28765.4 | . | -29159.1 | -8003.8 | -8460.5 | -7443.3 | -4246.3 |

*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 green price premium for Tokyo condominiums has changed over time for different income groups using the baseline hedonic model with the full set of control variables (including buyer characteristics) as described above. Following the introduction of the Tokyo green labelling system, the first year with a sufficiently large number of transactions was 2005. Figure 1 shows how green labelled and non-labelled condominiums developed relative to the 2004 average. For simplicity, only two income groups (above and below median) are considered here. After controlling for a large number of variables, the estimation results indicate green labelled condominiums bought by more affluent buyers commanded the highest premiums over the entire study period. Perhaps even more interestingly. the premium paid by below-average green buyers is by and large higher than the premium observed for above-average non-green buyers and substantially higher than for non-green transactions in the below average income peer group. The green premiums have generally declined in the more recent years of the analysis from 2007/8 onwards but the price differentiation between the green and the non-green products is still very clear. It is important to bear in mind, however, that the development of the green premium is not merely a reflection of the demand and supply balance of labelled properties but was probably also influenced by the implementation of environmental policies by the Japanese government, typically taking the form of subsidies and favourable tax treatments of green investments.

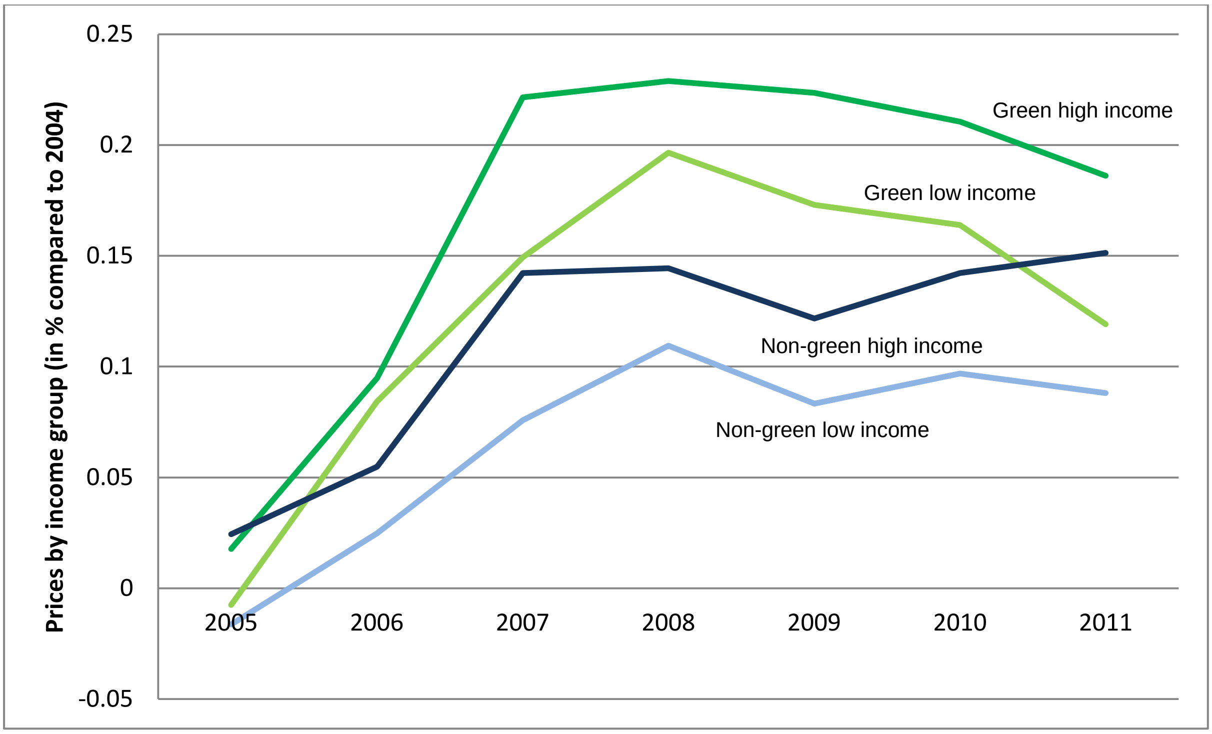


*Figure 1: Estimation results of condominium prices relative to 2004 levels in % (0.25=25%) by income group and labelling status of the purchased unit. Lower incomes <¥7.5 million, higher incomes ≥¥7.5 million, R-sq=0.80, N=23,922*

***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 for asking and transaction prices. Taking into account buyer characteristics, 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 acquired primarily by higher income households who are prepared to pay a premium for owning and occupying a green-labelled property. Conversely, the lower price premiums found for below-median income groups may be reflective of the tighter budget constraints they face and they may discount possible future cash savings via lower utility bills more heavily due to these constraints on their ability to acquire additional up-front capital for buying the bundle of goods proxied by the Tokyo green label.

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 that the awareness of green buildings increased in the Japanese residential market in the years following introduction of the Tokyo Green Label and that the buyer segment actively seeking to invest in their value is expanding. A further possibility is an increase in the supply of green buildings which may have led to a levelling off of the observed price premia. However, further analysis is required to ascertain whether the absence of the premium in the most recent 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, it is important to bear in mind that the Tokyo labelling system is based on applications from developers, i.e. it only indicates a building's *hypothetical* environmental performance at the time of development. It is possible that buyers may be reluctant to pay higher premia for energy efficiency and cost savings unless they are proven *in operation*.

Similarly, 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. Hence, we cannot rule out 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. More detailed information on the cost premium for constructing green condominium buildings would be required for this profitability calculation.

Furthermore, it is also uncertain how the emerging green building segment will be embedded in the broader housing market that comprises mainly of existing stock. Under the current system, green labels only cover newly developed buildings, but for green building policies to be more effective the extension of labels to existing stock 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. This may shift the aggregate demand curve downwards, possibly in a more pronounced manner for new construction and newly constructed green buildings than for the general existing housing stock. 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 affected by more stringent environmental regulations to be implemented in future (Takagi and Shimizu, 2010) but it is difficult to foresee how Japanese eco labels for buildings will adapt to these long-term changes in market conditions.

***Acknowledgment:***
*The continuous support of the Cambridge University Land Society in enabling the research activities of the CULS Fellow is gratefully acknowledged.*

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**Appendix 1: Variable names and data sources for Tokyo case study**

| Symbol | Variable | Content | Unit | Source |
|---|---|---|---|---|
| *green* | Green label dummy | Green building = 1<br>Other building = 0 | (0,1) | Tokyo Metropolitan Government |
| *trans* | Transaction price dummy | Transaction price=1<br>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. | meters | Real Estate Economic Institute |
| *Bus* | Bus dummy | bus-transportation area=1<br>walk-transportation area=2 | (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. | minutes | VAL Institute |
| *TU* | Total unit | Total units of condominium | unit | Real Estate Economic Institute |
| *Land* | Site area | Site area of condominium | $m^2$ | |
| *TA* | Total building area | Total building area of condominium | m2 | Real Estate Economic Institute |
| *Cost* | Management Cost | Property Management Cost | 10000 yen/month | RECRUIT |
| *ISP1* | With Housing performance evaluation report A dummy | With Housing performance evaluation report A=1<br>Without Housing performance evaluation report A=2 | (0,1) | RECRUIT |
| *ISP2* | With Housing performance evaluation | With Housing performance evaluation report B=1 | (0,1) | RECRUIT |

| | | | | |
|---|---|---|---|---|
| | report B dummy | Without Housing performance evaluation report B=2 | | |
| *MG1* | Management type(A) dummy | Management type is A=1<br>other =0 | (0,1) | RECRUIT |
| *MG2* | Management type(B) dummy | Management type is B=1<br>other =0 | (0,1) | RECRUIT |
| *Corner* | corner dummy | The location of unit is corner =1<br>Other location =0 | (0,1) | Real Estate Economic Institute |
| *STD* | Studio type dummy | Floor space 30 square meters or less =1<br>Floor space over 30 square meters = 0 | (0,1) | Real Estate Economic Institute |
| *RL1* | Leasehold(A) dummy | Land right is leasehold(Type A)=1<br>other =0 | (0,1) | RECRUIT |
| *RL2* | Leasehold(B) dummy | Land right is leasehold(Type B)=1<br>other =0 | (0,1) | RECRUIT |
| *TR* | Rate of Sales | Rate of sales in first month | (%) | Real Estate Economic Institute |
| $LU_g$ *(g=0,…,G)* | Land Use regulation dummy | *g*-th Land use regulation area=1 (residential, office, industrial)<br>other =0 | (0,1) | Real Estate Economic Institute |
| *Income* | Household income | Annual income of household | 10000 yen | RECRUIT |
| $HD_h$ *(h=0,…,H)* | Employment status dummy | *h*-thEmployment status of Head of household =1,<br>other=0 | (0,1) | RECRUIT |
| $WD_i$ *(i=0,…,I)* | Job type dummy | *i*-th job type =1,<br>other=0 | (0,1) | RECRUIT |
| $YD_j$ *(j=0,…,J)* | Business type dummy | *j*-th business type =1,<br>other=0 | (0,1) | RECRUIT |
| $LD_k$ *(k=0,…,K)* | Location (ward) dummy | *k*-th administrative district =1,<br>Other district =0. | (0,1) | Real Estate Economic Institute |
| $RD_l$ *(l=0,…,L)* | Railway line dummy | *l*-th railway line =1<br>Other railway line = 0. | (0,1) | Real Estate Economic Institute |
| $D_m$ *(m=0,…,M)* | Time dummy (yearly) | *m*-th year =1<br>Other year =0. | (0,1) | RECRUIT |

## Appendix 2: Full regression results of Tokyo case study

| | (1) Baseline | (2) Robust reg | (3) OLS with | (4) Income low | (5) Income | (6) Income | (7) Income high |
|---|---|---|---|---|---|---|---|

| | OLS log price | log price | HH char log price | log price | medium low log price | medium high log price | log price |
|---|---|---|---|---|---|---|---|
| green | 0.0482*** | 0.0428*** | 0.0475*** | 0.0368*** | 0.0389*** | 0.0511*** | 0.0589*** |
| | (14.43) | (13.00) | (14.38) | (6.00) | (6.82) | (7.82) | (7.13) |
| trgreen | -0.00552 | -0.00592 | -0.00552 | -0.00111 | -0.000849 | -0.00888 | -0.0132 |
| | (-1.44) | (-1.58) | (-1.46) | (-0.17) | (-0.14) | (-1.21) | (-1.36) |
| trans | -0.0383*** | -0.0351*** | -0.0383*** | -0.0435*** | -0.0417*** | -0.0336*** | -0.0330*** |
| | (-19.93) | (-20.20) | (-20.13) | (-12.88) | (-12.09) | (-9.66) | (-7.31) |
| sqft | 0.0243*** | 0.0251*** | 0.0248*** | 0.0204*** | 0.0281*** | 0.0225*** | 0.0255*** |
| | (48.74) | (88.08) | (43.78) | (16.18) | (33.19) | (31.69) | (31.91) |
| sqft_squared | -0.0000642*** | -0.0000712*** | -0.0000686*** | -0.0000435*** | -0.000104*** | -0.0000612*** | -0.0000680*** |
| | (-16.85) | (-34.66) | (-15.79) | (-4.81) | (-16.70) | (-11.59) | (-11.41) |
| ts | -0.0110*** | -0.0103*** | -0.0106*** | -0.00858*** | -0.00856*** | -0.0101*** | -0.0141*** |
| | (-38.81) | (-41.91) | (-37.39) | (-18.55) | (-16.12) | (-18.20) | (-16.05) |
| bus | -0.0185*** | -0.0198*** | -0.0189*** | -0.00890 | -0.0277** | -0.0445*** | -0.0191 |
| | (-3.81) | (-4.05) | (-3.89) | (-1.24) | (-3.12) | (-4.45) | (-1.19) |
| busTS | -0.00593*** | -0.00722*** | -0.00578*** | -0.00618*** | -0.00544*** | -0.00601** | -0.00511* |
| | (-10.15) | (-14.38) | (-9.94) | (-7.78) | (-5.77) | (-2.82) | (-2.33) |
| TA | -3.57e-08 | 1.94e-08 | -3.55e-08 | 9.10e-08 | 7.39e-08 | -4.30e-08 | -0.000000219*** |
| | (-1.20) | (0.75) | (-1.20) | (1.46) | (1.44) | (-0.82) | (-3.40) |
| ISP1 | 0.00644* | 0.00503* | 0.00642* | 0.00453 | 0.00219 | 0.00600 | 0.00457 |
| | (2.48) | (2.12) | (2.50) | (1.01) | (0.50) | (1.25) | (0.66) |
| ISP2 | 0.00687*** | 0.00328 | 0.00662*** | 0.00959** | 0.00156 | 0.00197 | 0.0145** |
| | (3.44) | (1.81) | (3.34) | (2.61) | (0.42) | (0.53) | (3.13) |
| MG1 | 0.00412 | 0.00341 | 0.00169 | 0.000283 | 0.00373 | 0.00171 | 0.00872 |
| | (1.75) | (1.58) | (0.72) | (0.07) | (0.87) | (0.39) | (1.59) |
| MG2 | 0.0203*** | 0.0194*** | 0.0167*** | 0.0157** | 0.0123* | 0.0174** | 0.0139 |
| | (6.53) | (7.03) | (5.44) | (2.69) | (2.14) | (3.04) | (1.96) |
| RL1 | -0.00901*** | -0.00728*** | -0.00481* | -0.0111** | 0.0000933 | 0.00464 | -0.0118 |
| | (-3.98) | (-3.48) | (-2.11) | (-2.80) | (0.02) | (1.17) | (-1.85) |
| RL2 | -0.0412*** | -0.0472*** | -0.0383*** | -0.0556*** | -0.0173 | -0.0241 | -0.0436 |
| | (-3.68) | (-4.60) | (-3.52) | (-3.37) | (-0.85) | (-1.15) | (-0.86) |
| corner | 0.0199*** | 0.0186*** | 0.0187*** | 0.0255*** | 0.0190*** | 0.0200*** | 0.0132** |
| | (9.59) | (9.71) | (9.09) | (6.55) | (5.21) | (5.13) | (2.77) |
| structure | 0.0171 | 0.0148 | 0.0147 | 0.0257* | 0.00989 | -0.00178 | -0.00183 |
| | (1.62) | (1.58) | (1.45) | (2.47) | (0.67) | (-0.13) | (-0.04) |
| TR | -0.000410*** | -0.000357*** | -0.000403*** | -0.000267*** | -0.000408*** | -0.000401*** | -0.000332** |
| | (-9.70) | (-9.03) | (-9.64) | (-3.50) | (-5.54) | (-4.91) | (-3.16) |
| tt | -0.00152*** | -0.00183*** | -0.00150*** | -0.00176*** | -0.00266*** | -0.000645 | -0.000251 |
| | (-8.65) | (-12.55) | (-8.70) | (-6.01) | (-9.53) | (-1.79) | (-0.51) |
| FAR | 0.0000476*** | 0.0000618*** | 0.0000433*** | -0.00000242 | 0.0000367* | 0.0000218 | 0.0000743*** |
| | (4.74) | (7.72) | (4.37) | (-0.10) | (1.97) | (1.24) | (3.83) |
| comm | 0.0134*** | 0.0160*** | 0.0138*** | 0.0395*** | 0.0163* | 0.0136* | -0.00963 |
| | (3.94) | (5.51) | (4.09) | (6.29) | (2.29) | (2.22) | (-1.43) |
| indust | -0.0281*** | -0.0246*** | -0.0271*** | -0.0133** | -0.0163** | -0.0254*** | -0.0187** |
| | (-10.13) | (-10.41) | (-9.87) | (-2.65) | (-3.11) | (-4.76) | (-2.65) |
| rental | -0.0000578*** | -0.0000519*** | -0.0000552*** | -0.0000164* | -0.0000411*** | -0.0000685*** | -0.0000841*** |
| | (-13.79) | (-13.34) | (-13.26) | (-2.07) | (-5.36) | (-8.45) | (-8.40) |
| old | -0.0000255*** | -0.0000323*** | -0.0000241*** | -0.0000383** | 0.00000222 | -0.0000350** | -0.00000636 |
| | (-3.83) | (-5.25) | (-3.66) | (-3.22) | (0.19) | (-2.74) | (-0.35) |
| strc2 | 0.0727*** | 0.0730*** | 0.0686*** | 0.0679*** | 0.0506*** | 0.0606*** | 0.0587 |
| | (6.93) | (7.78) | (6.80) | (6.53) | (3.50) | (4.54) | (1.40) |
| officew | 0.000331*** | 0.000320*** | 0.000323*** | 0.000260*** | 0.000270*** | 0.000349*** | 0.000259*** |
| | (20.92) | (22.98) | (20.69) | (9.15) | (8.93) | (11.90) | (6.39) |
| cost | 0.00870*** | 0.00743*** | 0.00841*** | 0.00467* | 0.00916*** | 0.00599*** | 0.00701*** |
| | (10.46) | (10.87) | (10.23) | (2.51) | (6.62) | (4.00) | (4.18) |
| age | | | 0.00101*** | 0.00121*** | 0.000303 | 0.00139*** | 0.000540 |
| | | | (7.93) | (5.22) | (1.37) | (4.69) | (1.79) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| number | | | -0.00336$^{**}$ | 0.00186 | 0.0274$^{***}$ | 0.0434$^{***}$ | 0.0288$^{***}$ |
| | | | (-2.97) | (0.78) | (8.41) | (11.40) | (7.06) |
| childdummy | | | -0.00188 | 0.000180 | 0.00270 | 0.00000949 | -0.00812 |
| | | | (-0.89) | (0.03) | (0.72) | (0.00) | (-1.85) |
| first | | | -0.0186$^{***}$ | -0.0150$^{**}$ | -0.0157$^{***}$ | -0.00730 | -0.00377 |
| | | | (-7.38) | (-3.05) | (-3.45) | (-1.41) | (-0.71) |
| invest | | | -0.0337$^{*}$ | 0.0520 | -0.0412 | -0.122$^{***}$ | -0.0621 |
| | | | (-2.35) | (1.26) | (-1.52) | (-4.15) | (-1.94) |
| hd4 | | | 0.0133$^{***}$ | 0.0263$^{***}$ | 0.0166$^{*}$ | 0.00768 | 0.00976 |
| | | | (3.71) | (5.15) | (1.97) | (1.19) | (1.23) |
| hd6 | | | 0.0620$^{***}$ | 0.0930$^{***}$ | 0.0432$^{***}$ | 0.0269$^{*}$ | 0.0243 |
| | | | (7.95) | (5.15) | (3.57) | (2.14) | (1.77) |
| wd7 | | | 0.00631$^{*}$ | -0.00227 | -0.00841 | 0.00166 | 0.0216$^{***}$ |
| | | | (2.26) | (-0.48) | (-1.43) | (0.35) | (3.59) |
| wd8 | | | 0.0190$^{***}$ | 0.0153$^{**}$ | 0.00885 | -0.00864 | 0.0131$^{*}$ |
| | | | (6.63) | (2.65) | (1.72) | (-1.47) | (2.20) |
| wd9 | | | 0.0248$^{***}$ | 0.0196 | -0.00798 | 0.00849 | 0.00796 |
| | | | (4.01) | (1.44) | (-0.59) | (0.72) | (0.73) |
| yd6 | | | 0.0178$^{***}$ | 0.0110 | 0.00814 | 0.00528 | 0.00669 |
| | | | (6.01) | (1.80) | (1.24) | (1.09) | (1.15) |
| _cons | 7.518$^{***}$ | 7.501$^{***}$ | 7.482$^{***}$ | 7.437$^{***}$ | 7.313$^{***}$ | 7.480$^{***}$ | 7.515$^{***}$ |
| | (177.85) | (221.20) | (174.97) | (113.39) | (107.18) | (117.31) | (56.14) |
| *N* | 23922 | 23922 | 23922 | 6038 | 6982 | 6012 | 4568 |
| $R^2$ | 0.810 | 0.829 | 0.814 | 0.793 | 0.803 | 0.846 | 0.855 |
| adj. $R^2$ | 0.809 | 0.828 | 0.813 | 0.788 | 0.799 | 0.842 | 0.850 |
| *AIC* | -29921.2 | . | -30403.8 | -8982.8 | -9474.5 | -8421.7 | -5171.7 |
| *BIC* | -28765.4 | . | -29159.1 | -8003.8 | -8460.5 | -7443.3 | -4246.3 |