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The Economic Value of Green Office Buildings in Tokyo*

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Abstract

This study estimates the economic value of green buildings in Tokyo's office market. We found, on average, a green label gained a premium of about 4% on contracted rent, but this premium lost its significance after we employed propensity score matching. We also estimated the green premiums for Tokyo's submarkets using clustering analysis. We found that, although the green label's premium was weak in a market focused on new, large-scale office buildings constructed only a few years ago, it had a statistically significant effect, adding approximately 10% of value, for older, medium-sized office buildings constructed several years ago. However, the latter drops to around 5.6% and becomes statistically insignificant after we control for the characteristics of tenants in the buildings. Our findings suggest that a green label does not create an economic premium by itself. Instead, it creates a premium through a signal to the market. As a result, tenants with high energy and resource efficiency and companies who have strong sense of social responsibility are willing to pay more for such labels, and thus, have a larger probability of moving into a building with a green label.

Keywords; green building, green label, hedonic approach, propensity score matching, clustering

JEL Codes: G51; M14; D92

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1. Introduction

Recent decades witness a marked economic growth in East Asian countries, such as China, and the relationship between economic growth and environmental burden has also be scrutinized over the last decade. The focus on these issues has become even stronger as the connection between global warming and increases in carbon compounds—which have risen sharply in the process of economic growth—has become clear and as global warming has manifested in the form of visible phenomena such as the destruction of existing ecosystems and rising sea levels.

The connection between economic growth and environmental burden has long been debated in the field of environmental economics. When environmental problems are interpreted as domestic issues, the debate is over environmental destruction and pollution induced health problems. However, in recent years, as economic growth has accelerated, environmental pollution related crises that used to occur every few decades have begun to occur every few years, shining a spotlight on this rapid change.

The "rapid economic growth" that occurred in Japan in the 1950s and 60s is often scorned in comparison to the post-Industrial Revolution economic growth in Britain-- its associated environmental burden, and the subsequent economic growth in other European countries. But it is accurate to say that Japan's growth was concentrated in an extremely short period of time. Similar pattern was found during the recent economic growth in East Asian countries, like China.

Amid such conditions, academic researchers and policy makers have begun to point to the importance of providing green buildings with a low environmental burden and high environmental performance (hereafter referred to as "green buildings"), which affect approximately half of the global carbon compound emissions. This trend resembles the push for green vehicles in the automobile industry. A great deal of research has been published debating on the economic efficiency of green buildings (see, for example, Eichholtz, Kok and Quigley, 2010). In short, if green buildings with high environmental performance come at a higher premium (i.e., rent and price) than buildings that are not environmentally conscious, it becomes possible to convert the stock of real estate into real estate with high environmental performance through market mechanisms and, as a result, the environmental burden can be reduced, even without strong policy intervention.

These are the circumstances under which the "environmental certification system" for real estate has emerged, with standards for environmental performance determined exogenously and objectively by a third party. Since BREEAM, the world's first environmental valuation system, was presented in the UK in 1990, other systems like the US' LEED (1996) and France's HQE (1996) have also been established. Such systems have spread globally, with Europe's pension fund group establishing GRESB, a system that evaluates the sustainability-consciousness of real estate companies and their portfolios, and Japan introducing it into most J-REITS (Japanese real estate investment trusts).

Since the Ministry of Land, Infrastructure, Transport and Tourism initiative CASBEE was announced in 2001, Japan has established a variety of environmental certification systems in the public and private sectors, including CASBEE Real Estate (2009), which was customized for easy application in real estate developments and transactions, the DBJ Green Building Certification developed by the Development Bank of Japan, and SMBC Sustainable Building Evaluation Financing developed by Sumitomo Mitsui Bank.

This study focuses on the office market in Tokyo, a city with one of the highest concentration of green office buildings in the world. Its goal is to compile a unique and rich micro-data on rents, green labels and green building performance, and provide rigorous empirical evidence to demonstrate whether the existing environmental certification system creates an economic premium for office rent. Aside from the city's size, this study focuses on Tokyo because we believe it has distinctive historical characteristics that relate to Japanese environmental policy.

As mentioned, Japan achieved miraculous economic growth in the 1950s and 60s. However, the downside was the growth in discouraging environmental pollution problems. In recent years, people have pointed to the high levels of air pollutants such as PM2.5 in China; however, levels in Tokyo at the time were more than 10 times those in Beijing today, causing extremely serious problems with pollution in the air, soil, rivers, and seas. Amid such conditions, the environmental issues became socioeconomic issues and, as environmental technology developed, environmental standards reached the highest levels, exemplified by green vehicles and the like.

However, while green buildings have received attention in Tokyo for more than a decade since the environmental certification systems were established, the share of certified environmentally friendly real estate is only 2% in terms of the number of buildings and 12% in terms of area, indicating that we are still in the development stages of making the overall stock of real estate certified environmentally friendly. We believe that environmental certification has not spread throughout the entire real estate market because, due to the environmental pollution problems that occurred under rapid economic growth and energy conservation policies following the oil crisis, an environmentally conscious social system had already been constructed. As such, substantial progress toward green buildings is being made and some point out that environmental certification evaluation may not serve as a point of differentiation in the market.

Furthermore, some also note that environmental performance has become secondary because major earthquakes frequently strike Japan and earthquake resistance in preparation for large-scale disasters has been emphasized over environmental performance. As such, although earthquake resistance evaluation is required in the performance evaluations of structures, environmental performance evaluation is voluntary.

As this is the case, when conducting a positive analysis to determine whether environmental certification evaluation creates an economic premium, we first pay attention to the type of characteristics present in real estate where environmental certification is prevalent. In other words, if obtaining environmental certification is voluntary, we must clarify why some building owners pursue this path. Furthermore, as revealed by Eichholtz, Kok and Quigley (2009), it is important to look not only at overall building characteristics such as earthquake resistance but also at who the tenants will be. In the analysis of the price formulation of real estate value, some have indicated that there may be under-formulation bias due to a large number of unmeasurable variables (Ekeland, Heckman and Nesheim (2004)), and such problems need to be carefully identified.

Taking those problems into consideration, this study aims to empirically determine whether environmental certification evaluation creates an additional economic premium in the office market in Tokyo, a city where offices that meet high environmental standards are already concentrated. If it does create a premium, we will determine what the market looks like while also taking into account the local characteristics of tenants in the office buildings with environmental certification and in the buildings without it.

The remainder of the paper is organized as follows: in the next section, we provide a thorough literature review; in section 3, we introduce the baseline estimation model and data; section 4 presents our empirical strategy and the estimation results; and the last section concludes.

2. Literature Review

Several pioneering studies have provided important insights into green buildings in the office market[1] The seminal paper by Eichholtz, Kok and Quigley. (2010) provided the first systematic analysis of the impact of environmentally sustainable building practices on economic outcomes as measured in the marketplace. They found that buildings with a "green rating" could command rental rates that were roughly 3% higher per square foot than otherwise identical buildings after controlling for the quality and the specific location of the office buildings. Premiums in effective rents were even higher, above 7%. Selling prices for green buildings were higher by about 16%. The percent increase in rent or value for a green building was systematically greater in smaller or lower-cost regions or in less expensive parts of metropolitan areas. Apparently, the private market did incorporate the "green" certification information in the determination of rents and asset prices. Fuerst and McAllister (2011) also used a hedonic approach to confirm that environmental certification creates an economic premium in terms of rent and asset value in the US commercial real estate market.

Most of the studies have verified the existence of an economic premium for "greenness." Many of these use data on the US office market because of the ease of obtaining such data. However, this highlights the limitations of the results and raises the question as to whether they can be generalized to other locations and periods.

Deng, Li and Quigley (2012) and Zheng et al. (2012) were the first studies to demonstrate that environmental certification creates an economic premium in the real estate markets of Asia. In Deng, Li and Qugiley (2012), they adopted a two-stage research design. In the first stage, a hedonic pricing model was used based on transactions involving green and non-green residential units in 697 individual projects or estates. In the second stage, the fixed effects estimated for each project were regressed on the locational attributes of the projects as well as control variables for a Green Mark (GM) rating. Their results suggested that the economic returns on green buildings were substantial. The returns varied by Green Mark category – both Platinum and Gold were positive and statistically significant. Green Mark Platinum remained significant using propensity score matching (PSM), the nearest neighbor matching of control and treatment samples. The study provided insight about the operation of the housing market in one country but the policy implications about the economic returns to sustainable investments in the property market may have broader applications for emerging markets in Asia.

Zheng et al. (2012) used two unique geo-coded micro-data sets to explore the nascent "green housing market" in Beijing, from both the supply and demand sides. Based on

[1] See, for example, Eichholtz, Kok and Quigley (2009), (2010), Eichholtz and Quigley (2012), Fuerst and McAllister (2011), Miller et al. (2008), and Reichardt et al. (2012).

Google searches, they built a sample that contained information on whether a certain housing complex green-related characteristics were emphasized during marketing, focusing on information that developers wished to convey to potential buyers. The study found that a nascent "green housing market" did exist in Beijing. They suggested that the introduction of a standardized official certification program would help "green" buyers find units and accelerate the advance of China's nascent green real estate market.

Based on a China's housing market data, Deng and Wu (2014) suggested a potential mismatch that developers face between outlays and benefits in the residential green building sector and how this mismatch could impede further development of green residential properties. The study found that the "green price premium" of residential development comes largely during the resale phase relative to the presale stage. The premium for GM-rated units was about 10% at the resale stage compared to about 4% during the presale stage. This implies that while developers pay for almost all of the additional costs of energy efficiency during construction, they share only part of the benefits associated with such green investments.

In addition to the above studies, Zheng, Wu and Kahn(2008) and Zheng et al. (2012) found significant price premiums for green properties in the Chinese housing market. Moreover, Deng, Li and Quigley (2012) found substantial economic returns on green buildings in Singapore. Kahn and Kok (2014), as well as Hyland et al. (2013), arrived at similar conclusions for the Californian and Irish housing market, respectively.

There are several studies on the green premium in Japan's housing market. Shimizu (2010, 2013) employs the hedonic model and shows that new condominiums with "green labels" in Tokyo command a premium of approximately 5.8% in their offer prices and 4.7% in their transacted prices. Such positive premiums are further verified by Yoshida and Sugiura (2015). Their findings echo the studies on green premiums in other countries' residential property markets (Banfi et al., 2005; Fuerst et al., 2015; Brounen and Kok, 2011; Zheng et al., 2012; Deng et al., 2012; Kahn and Kok, 2014; Hyland et al., 2013).

Fuerst and Shimizu (2016) used a unique transaction database of condominiums in the Tokyo metropolitan area and a hedonic analytical framework. They found that green buildings commanded a small but significant premium on both the asking and transaction prices. As far as they knew, their study was the first one on green buildings' economic premiums based on a hedonic model incorporating "buyer characteristics." However, further analysis revealed that this premium was primarily driven by wealthy households who exhibited a higher willingness-to-pay for eco-labeled condominiums, both as a total amount and as a fraction of the total sales price. They, therefore, concluded that eco-labels were perceived as representing luxury goods in the Japanese housing market rather than a means to save money on lower utility bills.

Based on the prior studies described, our study uses Deng, Li and Quigley (2012) and Fuerst and Shimizu (2016) as a starting point to build the following empirical model. First, there may be systematic differences in building attributes between green and non-green buildings. Without carefully controlling for such differences, researchers will obtain a biased estimate of the green premium. PSM is widely used to mitigate this problem. However, if most of the green buildings are concentrated in a specific submarket (for instance, newer and larger-size buildings), the PSM results will mainly show the green premium in that submarket and other submarkets with less green buildings will be under-represented. In this study, we use PSM with *clustering analysis* to address this issue to reveal the green premiums in various submarkets. We then conduct PSM again, even in specified clusters where economic premiums were detected, and also conduct robustness tests.

Second, there may be some systematic differences in dweller attributes between green and non-green buildings, namely, firms and residents may sort themselves along the economic performance dimension of the building. Fuerst and Shimizu (2016) estimated a hedonic model that considered household characteristics, such as income. They found that the higher the income group, the higher the economic value was. In the office market, firms with stronger social responsibility or a higher sensitivity to energy expenditure may have a higher willingness-to-pay for green office space, and thus, we should observe a larger share of such firms in green buildings compared to non-green buildings. One merit of our data set is that we have some information on tenant characteristics. We are able to include such information in our model to investigate whether the green label creates the premium by itself or whether it triggers tenant sorting so the observed green premium is the differential of willingness-to-pay among different tenant groups.

With environmental technology continuing to develop, we are confident that this study demonstrates a new perspective in the field of measuring the economic premium created by environmental certification of real estate. The study not only looks at the office market in Tokyo—which boasts the largest stock of office buildings in the world—but also carefully uses PSM to differentiate between office buildings with and without environmental certification and verifies the effect of environmental certification while controlling for tenant attributes.

3. Estimation model and data

3.1 Estimation model

We estimate a price function for new contracts to rent office space by specifying the presence or absence of the green label. The new rent contract for office space is a function of the characteristics of the office building and the green label certification condition. It is generally expressed as a hedonic price model, as shown below.

$$R_i = \mathrm{h}(green_i, x_i), \qquad (1)$$

where R_i on the left-hand side of equation (1) represents the new rent contract of completed contract case i; $green_i = (0, 1)$ is the green label dummy; $x_i' = (x_{1i}, x_{2i}, \dots, x_{ni})$ is the vector that expresses the n characteristics of the completed contract case i. In this study, we employ the log-linear function form:

$$\ln R_i = \alpha + green_i' \cdot \beta + x_i' \cdot \gamma + \varepsilon_i, \qquad (2)$$

where $\ln R_i$ (new contract rent, in logarithm) is the dependent variable, α is the constant term, $green_i$ and x_i are the independent variables, and ε_i is the error term. Here, the parameters to be estimated are α, β, γ, and $\beta' = (\beta_1, \dots, \beta_n)$; and $\gamma' = (\gamma_1, \dots, \gamma_n)$ are the vectors of the coefficients corresponding to each independent variable.

Next, we describe the independent variable x_i used in equation (2). First, we apply gross building area, standard story area, and number of above ground stories as the variables measuring the scale of an office building. Second, we use age and whether a renovation had been carried out as the variables to measure how new the building is. Additionally, we apply travel time to the nearest metro station and the presence or absence of office specifications that tenants find appealing such as a higher floor, individual controlled air conditioning, and automated security, as indicators of attractiveness.

Further, we add to the model an office area dummy and a dummy for the time the contract was completed to control for omitted variables in space and time. We use an office area dummy variable to capture the effects of location on rent, obtained by dividing a typical office area in Tokyo's 23 wards into 50 areas. In Tokyo, tenants tend to be concentrated in developed areas that are convenient and popular office areas. These include Marunouchi, Otemachi, Shinjuku, Shibuya, Shinagawa, Nihonbashi, Shinbashi, Toranomon, Akasaka, and Roppongi. In these popular areas, rents tend to be high, even for properties that are of medium- to small-scale or old. Conversely, in areas that are not popular as office areas, it is difficult to observe a contract with a high rent, even if the property is large and new.

The demand and supply conditions in the market at the time the property is offered affects the rent. A two-year sample period, from January 2013 to December 2014, was divided into eight quarters and quarterly dummy variables were constructed according to the time the contract was completed.

3.2 Data

We collect and then merge the data on rents and green labels to create the dataset for analysis. First, for the rent data, we use the completed contract case database for office buildings collected by the Xymax Corporation.[2] In Japan, most rent data are available on offered rents. However, there may be a divergence between the offered rent and the contract rent due to a decision following negotiations between the property owner and the tenant. To achieve the objective of this study, we consider it preferable not to use the offered rent but rather the completed-contract rent, which reflects actual market conditions more accurately. Here, we use such completed-contract rent data on new contract rentals collected by Xymax.[3] Their database includes many variables measuring the characteristics of the buildings, including scale, such as gross building area; performance, such as the building's age and air-conditioning systems; location, such as the time to walk to the nearest metro station and the area in which the building is located; and the time period in which the contract was completed. Considering that the decision structure for the rental is generally determined by the area and the good or bad conditions of the office market at the time in question, the completed contract cases we use for analysis were set within Tokyo's 23 wards, with a gross building area of more than 300 *tsubo*, completed between January 2013 and December 2014. As a result, we extracted data on 2,689 buildings and 6,758 new rent contract cases as our sample.

Next, for the data on the presence or absence of a green label, we survey the homepages of organizations and the various companies granting the green label and collect and arrange the published information. For the analysis, we select the following green label systems: CASBEE, CASBEE for real estate, DBJ Green Building Certification, and

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[2] Xymax is one of the representative property management companies in Japan. https://www.xymax.co.jp/english/

[3] The data registered in the Xymax Corporation database are rent data based on completed contracts from within the implementation of real estate management operations. As of the end of December 2014, the company had accumulated information on around 5,300 properties and approximately 33,000 cases (in Tokyo's 23 wards, and a gross building area of more than 300 *tsubo*).

SMBC Sustainable Building Assessment.

There were three reasons for selecting these systems. First, in these systems, the certification is acquired by the building. This makes it possible to integrate the rent data and the green certification data by building, which enables us to conduct the analysis using the green label as one factor affecting rent.[4] Second, these are certification systems assessing comprehensive environmental performance, that is, they assess not only the energy-saving performance of the buildings but also aspects such as reduction of the environmental load, usefulness to users, and management policy.[5] Third, in these certification systems, a third party organization carries out the assessment based on the standards that these systems have established.

Our survey of the office buildings located in Tokyo's 23 wards showed that there eight buildings were under the SMBC Sustainable Building Assessment, 90 buildings under DBJ Green Building Certification, 77 buildings under CASBEE, and 36 buildings under CASBEE for real estate (as of November 2014).

We integrate data on green-label certification and data on the rents to use for the analysis. Specifically, for the dummy variable (hereafter, the green label dummy), if a building has acquired any one of the green labels used for the analysis, the green label dummy will take the value 1, and 0 otherwise. These dummy variables are merged with the rental data.

The data used for the analysis are comprised of 6,758 completed contract cases (2,689 buildings). Among them, we record 361 cases as having a green label dummy value of 1, which accounts for 5.3% of the sample.

4. Estimation strategy and results

4.1 Hedonic model estimation results

Table 1 lists the variables used for the analysis, and Column 1 of Table 2 shows the summary statistics.

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[4] Within the green label systems, there are those that carry out assessments and grant certifications on corporations and portfolios. However, as it is difficult to integrate such data with rent data on unit properties, they are excluded from the analysis.

[5] In Japan, the growth in the use of green label systems is still underway. Therefore, if we used only an individual certification system, the number of samples would have been insufficient for analysis. This is why we added information that considers if the building acquired certification from any one of the multiple systems. Although the detailed assessment items and standards are different in each of the systems used for analysis, they have in common the fact that they all assess comprehensive environmental performance. Therefore, we did not consider integrating their data into the analysis as a problem. There are various other systems that only assess energy saving performance. However, we excluded them from the analysis, as we decided it would become difficult to use them when interpreting the results.

Table 1 Variables and description

Variable	Content	Unit
New contract rent	The contract rent when newly entering into the building (not the offered price when it was being offered to tenants)	Yen/sqm
Green label dummy	Buildings granted a green label: 1 All others: 0	(0,1)
Gross building area	Gross building area of the building	sqm
Age	Number of years since construction	Year
Number of above-ground stories	Number of above-ground stories in the building	Stories
Standard story area	Standard story area of the building	sqm
Five city-center wards dummy	In the event that the building is located in one of the five city-center wards (Chiyoda Ward, Chuo Ward, Minato Ward, Shinjuku Ward, and Shibuya Ward): 1 All others: 0	(0,1)
Time to nearest station	The number of minutes to walk to the building from the nearest station	Minutes
Raised floor dummy	If a raised floor has been installed in the building: 1 All others: 0	(0,1)
Individual air conditioning dummy	If individual air conditioning has been installed in the building: 1 All others: 0	(0,1)
Automated security dummy	If automated security has been installed in the building: 1 All others: 0	(0,1)
Renewal dummy	If the building has been/is being renewed at the time the contract was completed: 1 All others: 0	(0,1)
Time of contract completion dummy	On preparing dummy variables for each time of contract completion(quarter), If the time the contract has been completed corresponds to the quarter : 1 All others : 0	(0,1)
Area dummy	On preparing dummy variables for each typical office area, in the event that there is a building: 1 All others: 0	(0,1)

Table 2 Summary dataset statistics

	Full Sample		Green-Label		Non-Green-Label	
	Number of Obsarvations = 6,758		Number of Obsarvations = 361		Number of Obsarvations = 6,397	
	mean	standard deviation	mean	standard deviation	mean	standard deviation
New contract rent	5,169.73	1,862.02	7,638.37	2,154.42	5,030.42	1,743.04
Green label dummy	0.05	0.22	1.00	-	0.00	-
Gross building area	18,928.33	37,444.15	61,717.76	80,973.86	16,513.61	31,669.82
Age	23.73	11.83	8.78	9.77	24.57	11.36
Number of above-ground stories	11.69	7.70	20.17	12.50	11.21	7.04
Standard story area	780.24	795.11	1,533.13	1,217.62	737.76	742.05
Five city-center wards dummy	0.77	0.42	0.86	0.35	0.76	0.42
Time to nearest station	3.36	2.31	2.98	1.80	3.38	2.34
Raised floor dummy	0.68	0.46	0.96	0.21	0.67	0.47
Individual air conditioning dummy	0.80	0.40	0.81	0.39	0.80	0.40
Automated security dummy	0.83	0.37	0.87	0.33	0.83	0.38
Renewal dummy	0.13	0.34	0.12	0.33	0.13	0.34

We carry out ordinary least squares (OLS) estimates based on equation (2); Column 1 of Table 3 shows the results. Based on our analysis in Section 1, we expect a significantly positive coefficient for the green label dummy. The estimation result of ＋0.0439 (0.0115) is positive and significant (the figures in parentheses are the standard errors). This shows that the new contract rent for buildings granted green labels was approximately 4% higher than other new rental contracts.

Table 3 Results of hedonic and probit regressions

	(1)	(2)	(3)
	OLS	Probit	OLS
	Baseline		PSM
Constant	7.8684***	-3.9439***	-74.6288
	(0.0318)	(0.5239)	(86.6478)
Green label dummy	0.0439***		-1.6673
	(0.0115)		(1.8874)
Gross building area (logarithm)	0.1074***	0.4199***	-6.0229
	(0.0090)	(0.1331)	(6.0873)
Age	-0.0089***	-0.0727***	-0.0628
	(0.0003)	(0.0045)	(0.0554)
Number of above-ground stories	0.0029***	-0.0146*	1.6052
	(0.0007)	(0.0083)	(1.6120)
Standard story area (logarithm)	0.0027	-0.0492	17.2996
	(0.0103)	(0.1522)	(17.8718)
Time to nearest station	-0.0238***	-0.0149	0.7583
	(0.0011)	(0.0178)	(0.7291)
Raised floor dummy	0.0040	0.0938	-2.9774
	(0.0058)	(0.1368)	(3.1113)
Individual air conditioning dummy	0.0051	0.1596*	-11.5097
	(0.0066)	(0.0970)	(11.7921)
Automated security dummy	-0.0118*	0.1633	12.8193
	(0.0067)	(0.1132)	(13.5811)
Renewal dummy	0.0334***	1.0639***	-5.7735
	(0.0079)	(0.1257)	(6.2213)
Time of contract completion dummy	Yes	Yes	Yes
Area dummy	Yes	Yes	Yes
Number of samples	6,758	6,758	722
Percentage of buildings with green label	5.34%		50.00%
adjusted R-squared	0.6770		0.9213
Log likelihood		-831.1474	
AIC		1814.2950	

Notes: Standard errors in the parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

These results suggest that obtaining the green label was an economically rational action that could be expected to earn higher returns. However, we should consider that there may be other factors that correlate with both the green label and office rents, which could lead to omitted variable bias.

Many of the buildings granted green labels were developed by major developers and REITs (Real Estate Investment Trusts); they are generally large in scale and relatively new. These types of developers have an abundance of financial strength compared to developers of medium- or small-scale building projects. Therefore, they are able to pay the costs necessary to acquire a green label. In some cases, they are willing to get involved in social responsibility activities and their shareholders and investors also demand that they make this effort. Therefore, it is possible that the conditions around green label certification will differ depending on the developer and development characteristics of the office building.

We also consider that the conditions for green certification would differ depending on the building's age. Based on the progress in construction technologies, such as improvement in insulation for building exteriors and higher equipment efficiency, the environmental performance of newly constructed office buildings is improving annually. An old office building, with inferior environmental performance, would need to carry out a preliminary survey and refurbishments to acquire a green label, both of which would incur costs. In addition, from the preliminary survey results, there would be little prospect of the building obtaining a high score and grade; thus, few owners of old office buildings would actually take the actions necessary to pursue green certification. Conversely, office buildings that have been newly constructed or are only a few years old will already have higher environmental performance in areas such as the building exterior and equipment. Thus, they would be able to acquire the green labels more easily. In particular, in the case of newly constructed office buildings, possibly, the design and construction may be carried out while keeping the green label certification in mind at the planning stage. Therefore, the refurbishment costs necessary for existing buildings would not be incurred. In other words, in an economic analysis of environmental considerations, a problem may exist where factors such as scale and newness become proxy variables for a green label.

Table 2, Columns 2 and 3 show the statistics of green and non-green office buildings. The average values for gross building area and age since construction for samples that were granted a green label were 61,717 m^2 and 8.78 years, respectively. In contrast, these values were 16,513 m^2 and 24.57 years, respectively, for samples that were not granted a green label, showing that these buildings tended to be of a small scale and older. In this study, it is difficult to distinguish between environmental performance and other characteristics. The question remains whether the estimation of +4.39% as the green label dummy coefficient is really attributable to the presence or absence of a green label or whether it comes from a mixture of the effects of scale, newness, location, and the period the contract was completed. Therefore, it is necessary to be cautious when explaining the coefficient of the green label dummy in the basic OLS regression.

We can also understand this issue from the perspective of the hedonic approach. We consider that the decision whether or not to acquire a green label is also affected by variables common to the rental hedonic model, such as size and newness, which leads to the endogeneity issue.

4.2 Estimation using propensity score analysis (1): The whole sample

This study employs the following two methods to address the endogeneity issue mentioned: (1) PSM (see subsection 3.2) and (2) stratification based on the propensity score (see subsection 3.3). In PSM, we first estimate a probit model of the probability of obtaining a green label (i.e., the propensity score). Next, based on the estimated propensity score, we create two similar groups, and let the large difference between these groups indicate the existence of a green label. Then, we proceed with the analysis by estimating the effect of a green label on new contract rent.

When processing the data using the propensity score, it is possible to take a constant degree of balance between the two groups with regard to the average value of the covariate, thereby making it possible to address endogeneity. In addition, because covariates of multiple dimensions are combined, this method enables a detailed analysis using clustering.

The variables are defined as follows:

Y_1: New contract rent, with green label granted;

Y_0: New contract rent, with green label not granted;

D: 1: When green label is granted to an office building;

0: When green label is not granted to an office building;

$\mathbf{x}$: Characteristics of an office building that can be observed as a covariate, where $\mathbf{x}$ is a vector of the components $(x_1, \ldots, x_i)$;

$\mathrm{P}(\boldsymbol{x}) = Pr(D = 1|\boldsymbol{x})$: Forecasted probability of a green label being granted to an office building with characteristics $\mathbf{x}$.

The effect of the green label on new contract rent, when treated as the difference between office buildings being granted or not granted a green label, is expressed as follows:

$$\mathrm{E}(Y_1|D=1)-\mathrm{E}(Y_0|D=0). \quad (3)$$

If the size or newness of a building affects whether it has a green label, it is possible that there is bias in the estimation effect. In other words, if new contract rent increases because of high quality and a transaction is concluded, irrespective of whether a green label is granted, the new contract rents in the office buildings that have not been granted green labels also increase. Therefore, we consider that the strict green label effect can be expressed as follows:

$$\Delta_{D=1}(\boldsymbol{x})=\mathrm{E}(Y_1-Y_0|P(\boldsymbol{x}),D=1). \quad (4)$$

This formula concerns office buildings that have been granted a green label and expresses the difference in the new contract rent between when a green label is granted and when it is not. Through this expression, if we know the new contract rent in an office building with a green label, we can simply extract the effect of the green label if it has not been granted. Because it is normally not possible to observe such "hypothetical" new contract rents, the value that represents this is assigned a weight by $\mathrm{P}(\boldsymbol{x})$ and the new rent is estimated from the new rents of office buildings without green labels. When this value is matched with the new contract rents of office buildings that have been granted green labels, the estimated value of the effect of a green label is expressed as follows.

$$\hat{\Delta}_{D=1}(x)=\frac{1}{n_1}\sum_{\substack{i=1 \\ \{D_i=1\}}}^{n_1}\left\{Y_{1i}(\boldsymbol{x_i})-\hat{E}(Y_{0i}|P(\boldsymbol{x_i}),D_i=0)\right\}, \quad (5)$$

where n_1 denotes the number of buildings that have been granted green labels. New rents at office buildings that have not been granted green labels, which are used as proxies, will have an expected value as follows.

$$\hat{E}(Y_{0i}|P(\boldsymbol{x_i}),D_i=0)=\sum_{\substack{j=1 \\ \{D_j=0\}}}^{n_0} W_i\big(P(\boldsymbol{x_i})\big)Y_{0j}, \quad (6)$$

where n_0 is the number of samples that have not been granted green labels and W is the weight assigned by $\mathrm{P}(\boldsymbol{x})$. In section 3.2, nearest neighbor matching is used to assign weights for comparisons. Under nearest neighbor matching, the matching is performed on office buildings with the nearest probability of being granted a green label, those that have been granted a green label, and those that have not been granted a green label. The new contract rent at an office building that has not been granted a green label but has a very similar probability (in terms of having a green label) to a green office building is used as a proxy for new contract rents.

Note that the following probit regression is used to estimate the probability of a green label being granted to an office building possessing $\mathbf{x}$ characteristics. Here, β is a vector of the elements $(\beta_1, \dots, \beta_i)'$.

$$\mathrm{P}(\boldsymbol{x}) = \Pr(D = 1|\boldsymbol{x}) = \Phi(\boldsymbol{x\beta}) = \int_{-\infty}^{x\beta} \frac{1}{2\pi} exp\left(-\frac{z^2}{2}\right) dz. \quad (7)$$

The study of the following office characteristics determines whether a green label is to be granted: gross building area (m^2), standard story area (m^2), above-ground stories (stories), age (years), area dummy, time to nearest station (minutes), raised floor dummy, individual air conditioning dummy, automated security dummy, and time of contract completion dummy.

The estimation results of the probit regression are reported in Column 2 of Table 3. The coefficient of age is significantly negative, which reflects that younger buildings are more likely to be granted green labels. Although the coefficients for raised floor, individual air conditioning, and automated security are not statistically significant at the 5% level, they all have a positive sign. Thus, we consider that there is a propensity for office buildings to be granted green labels when they are equipped with such facilities. We find that the coefficient of gross building area is positive, reflecting that green labels are more likely to be granted to larger buildings. The time to nearest metro station was not statistically significant.

These results indicate that the probability of acquiring a green label is higher for high-quality office buildings that are younger, larger, and better equipped. To satisfy the comprehensive environmental performance requirements for a green label, the exterior and the air conditioning need to be energy efficient, the plumbing system designed to conserve water, there needs to be greenery around the building, and there must be appropriate maintenance and good building management with respect to disaster and business continuity planning. We consider that unless the office building is large, it would be difficult to realize a sufficient plot size and business profitability to enable the establishment and sustainable management of such a building.

Table 4 shows the summary statistics of the datasets extracted from the nearest neighbor matching, using the propensity score that measures the probability of obtaining green versus non-green labels. To perform a one-to-one matching of green and non-green buildings, a sample size of 361 was set for each, for a total sample size of 722.

Before matching, the average value of gross building area was 61,717 m^2 for green buildings and 16,513 m^2 for non-green buildings. After matching, the difference was smaller, with a gross building area of 61,717 m^2 for green buildings and 48,572 m^2 for non-green buildings.

With regard to average age, before matching, the average age was 8.78 years for green buildings and 24.57 years for non-green buildings. After matching, the average age was 8.78 years for green buildings and 8.36 years for non-green buildings. Other variables were adjusted as well and by using PSM, the differences between the two groups reduced, enabling us to create similar samples.

Table 4 Summary statistics of dataset (after propensity score matching)

	Green-Label Number of obserrvations = 361				Non-Green-Label Number of observations = 361			
	mean	standard deviation	minimum	maximum	mean	standard deviation	minimum	maximum
New contract rent	7,638.37	2,154.42	3,025.00	16,649.60	7,625.18	2,283.37	2,420.00	13,612.50
Green label dummy	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00
Gross building area	61,717.76	80,973.86	1,785.06	379,447.90	48,572.06	56,058.70	1,100.83	263,996.70
Age	8.78	9.77	0.00	50.75	8.36	8.03	0.00	35.50
Number of above-ground storie	20.17	12.50	5.00	54.00	18.32	10.26	5.00	54.00
Standard story area	1,533.13	1,217.62	182.91	5,054.55	1,394.13	1,120.63	115.74	6,760.33
Five city-center wards dummy	0.86	0.35	0.00	1.00	0.84	0.37	0.00	1.00
Time to nearest station	2.98	1.80	0.00	10.00	2.81	2.16	0.00	10.00
Raised floor dummy	0.96	0.21	0.00	1.00	0.93	0.26	0.00	1.00
Individual air conditioning dur	0.81	0.39	0.00	1.00	0.82	0.38	0.00	1.00
Automated security dummy	0.87	0.33	0.00	1.00	0.89	0.31	0.00	1.00
Renewal dummy	0.12	0.33	0.00	1.00	0.09	0.28	0.00	1.00

Column 3 of Table 3 shows the estimation results of the hedonic approach for the sample, calculated using PSM. The estimated coefficient of the green label dummy is -1.6673 (1.8874) and is not a statistically significant, which means a green label does not bring in additional rent premiums. This result is quite different from what we obtained from the OLS regression in section 3.1.

It is important to note that the extracted samples are centered on large, newly constructed office buildings. We believe these are affected by those that matched the 361 green building sample and 6,391 non-green building sample in a one-to-one. Table 2 showed the average gross building area as 16,513 m^2 and average age of non-green buildings as 24.57 years. The averages of the same variables for non-green buildings in Table 4, using matching by propensity score, were 48,572 m^2 and 8.36 years, respectively. The data of the approximately 6000 non-green buildings that were not matched were excluded.

Therefore, we interpret the results in this section as follows: a green label has almost no effect or even a slightly negative effect on comparatively large and young office buildings. However, the effect on other office buildings is unknown. In the analysis of the PSM, it is problematic that the effect of a green label on medium- and small-sized and on old office buildings cannot be confirmed.

4.3 Estimation using a propensity score analysis (2): subsamples by clustering

To address the problem raised in the previous section, we divide the sample into five clusters based on the value of the propensity score. Since the properties with a low propensity score tend to be smaller and older, we should also be able to analyze the clusters of mid- to low-propensity scores.

To calculate the propensity score, we used the same method described in section 3.2. By using the estimated propensity scores, the sample is divided into five clusters. Five quantiles are used as the boundaries of these clusters and the number of samples in each cluster is nearly the same.

Columns 1 to 5 of Table 4 show the estimation results of the hedonic function for each cluster using the same method described in section 3.1. In cluster 5, which has the highest propensity score, the value is negative and nearly zero (-0.0058 (0.0105)). The covariates of stratum 5 show that the office buildings in the sample are large and young (in cluster 5, the average gross building area is 50,057 m^2 and average age 9.86 years). In cluster 4, the result is +0.1378 (0.0328), which is a significant and positive effect. Compared with cluster 5, the medium-sized and older office buildings in this cluster have a high propensity score (in cluster 4, the average gross building area is 14,789 m^2 and average age 22.13 years). We find there are no statistically significant effects in clusters 1 to 3 because the sample size ratio of green to non-green buildings is small, which means there are insufficient green buildings to estimate an effect. The effect of a green label on new contract rents is not uniform for all office buildings. Instead, it depends on the characteristics of the office buildings. Larger properties with green labels hardly show any effect, while mid-sized properties show a significant effect of more than +10%.

Table 5 Results of hedonic regressions (PS Clustering sample)

	(1) Cluster no.1	(2) Cluster no.2	(3) Cluster no.3	(4) Cluster no.4	(5) Cluster no.5
Constant	7.6919***	7.8393***	7.8943***	7.9906***	7.9708***
	(0.0785)	(0.0781)	(0.0816)	(0.0791)	(0.0695)
Green label dummy		0.2453**	-0.0343	0.1378***	-0.0058
		(0.1231)	(0.0950)	(0.0328)	(0.0105)
Gross building area (logarithm)	0.1556***	0.0961***	0.0801***	0.0967***	0.0767***
	(0.0216)	(0.0273)	(0.0238)	(0.0220)	(0.0167)
Age	-0.0073***	-0.0023**	-0.0074***	-0.0111***	-0.0130***
	(0.0007)	(0.0009)	(0.0022)	(0.0015)	(0.0008)
Number of above-ground stories	-0.0004	0.0027	0.0078***	0.0043**	0.0034***
	(0.0018)	(0.0027)	(0.0020)	(0.0019)	(0.0010)
Standard story area (logarithm)	-0.0452*	-0.0139	0.0104	-0.0008	0.0382**
	(0.0246)	(0.0309)	(0.0226)	(0.0230)	(0.0187)
Time to nearest station	-0.0240***	-0.0215***	-0.0247***	-0.0158***	-0.0218***
	(0.0027)	(0.0032)	(0.0024)	(0.0023)	(0.0022)
Raised floor dummy	0.0271**	-0.0083	0.0147	-0.0256*	-0.0078
	(0.0124)	(0.0134)	(0.0115)	(0.0133)	(0.0216)
Individual air conditioning dummy	0.0158	-0.0134	0.0116	-0.0172	-0.0099
	(0.0167)	(0.0175)	(0.0164)	(0.0140)	(0.0119)
Automated security dummy	-0.0495***	0.0078	0.0165	0.0025	0.0081
	(0.0151)	(0.0145)	(0.0166)	(0.0164)	(0.0136)
Renewal dummy	0.0202	-0.0208	0.0946**	0.0553**	0.0397**
	(0.0218)	(0.0233)	(0.0372)	(0.0239)	(0.0182)
Time of contract completion dummy	Yes	Yes	Yes	Yes	Yes
Area dummy	Yes	Yes	Yes	Yes	Yes
Number of samples	1,352	1,351	1,352	1,351	1,352
Percentage of buildings with green label	0.00%	0.22%	0.30%	2.22%	23.96%
adjusted R-squared	0.4669	0.5034	0.4852	0.6218	0.7684

Notes: Standard errors in the parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4 Verification of estimation robustness and extended model estimation

Here, we verify whether similar results can be obtained even when analyzing a homogeneous sample, and how the age of the building affects the impact of the green label over time. When we observe each of the clustered sample groups in subsection 3.3, we find office buildings with green labels with higher propensity scores than others. Although we extracted the samples through clustering next to those with relatively closer propensity scores, we may be able to further remove the effect caused by the covariates from each cluster. Therefore, we choose to conduct further PSM within the clustered sample groups, extract samples, and then estimate the hedonic function. Thus, we will be able to verify the effect of a green label in samples with greater homogeneity, which are not influenced by covariates.

Subsequently, we verify the effect of a green label based on the age of the buildings and how this changes over time. In the probit regression model in subsection 3.2, we learned that newer buildings were more likely to acquire green labels. Therefore, we can expect that even with clustered data, a certain relation will still exist between the age of the building and the green label dummy. We create our estimate based on a model that adds the green label dummy and the age as an interaction term into equation (2). There are only 30 cases in the data that have been granted green labels within the samples in cluster 4 where the age will be a true value instead of a dummy variable,

Column 2 of Table 6 shows the results of the hedonic function estimate after we extract the samples and conduct further PSM within cluster 4. The coefficient of the green label dummy is +0.1297 (0.0370), thereby being a significant result. This result is equivalent to those in subsection 3.3, proving the robustness of our analysis.

Next, Column 3 of Table 6 shows the estimation result of the model that included the age of the buildings and the green label dummy as interaction term. In cluster 4, the coefficient of the green label dummy is +0.3888 (0.0824), showing a significant positive result, and the coefficient of the interaction term of the green label dummy and the age of the building is -0.0131 (0.0039), showing a significant negative result. From these results, we can see newer buildings benefitting from the highly positive effect of being green labeled but this effect diminishes with time and, finally, there are no further effects at about 30 years from the original construction.

When we consider this, we believe it is because tenants are inclined to pay higher rent for comparatively more attractive office buildings. Office buildings that are large and new are implicitly meeting or exceeding environmental performance even without green labeling. Such buildings include various elements (e.g., attractive exteriors, building function specifications, location, special facilities such as business continuity plans, etc.) apart from a green label, and tenants are able to recognize good quality office buildings using this information. Moreover, because about a quarter of all large and new office buildings on the market have been granted a green label, we consider that the ubiquity of green labels is also a reason for these results. This helps to explain why the green label dummy loses its significance in cluster 5 in the PSM regression.

Table 6 Robustness check and expansion model

	(1)	(2)	(3)	(4)
		PSM	Cross term (Green×Age)	PSM+TSR
	Cluster no.4	Cluster no.4	Cluster no.4	Cluster no.4
Constant	7.9906***	9.0946***	7.9628***	9.6544***
	(0.0791)	(0.3604)	(0.0792)	(0.4914)
Green label dummy			-0.0131***	
			(0.0039)	
Green label dummy × Age	0.1378***	0.1191***	0.3888***	0.0556
	(0.0328)	(0.0366)	(0.0824)	(0.0380)
TSR Score				0.0116***
				(0.0035)
Gross Building Area (logarithm)	0.0967***	-0.1295	0.0991***	-0.1913*
	(0.0220)	(0.1113)	(0.0219)	(0.1039)
Age	-0.0111***	0.01	-0.0106***	0.0220**
	(0.0015)	(0.0101)	(0.0015)	(0.0088)
Number of above-ground stories	0.0043**	0.0118	0.0045**	0.0205*
	(0.0019)	(0.0090)	(0.0019)	(0.0105)
Standard strory area (logarithm)	-0.0008	0.0222	-0.0018	-0.0551
	(0.0230)	(0.1104)	(0.0229)	(0.0936)
Time to nearest station	-0.0158***	-0.024	-0.0158***	-0.0077
	(0.0023)	(0.0212)	(0.0023)	(0.0189)
Raised floor dummy	-0.0256*	-0.0159	-0.0268**	-0.0358
	(0.0133)	(0.0588)	(0.0133)	(0.0586)
Individual air conditioning dummy	-0.0172	-0.1664	-0.0179	-0.2976**
	(0.0140)	(0.1039)	(0.0140)	(0.1139)
Automated security dummy	0.0025	0.2029*	0.0059	-0.2327*
	(0.0164)	(0.1113)	(0.0163)	(0.1332)
Renewal dummy	0.0553**		0.0500**	
	(0.0239)		(0.0238)	
Time of contract completion dummy	Yes	Yes	Yes	Yes
Area dummy	Yes	Yes	Yes	Yes
Observations	1,351	60	1,351	51
Percentage of buildings with green label	2.22%	50.00%	2.22%	50.98%
Adjusted R^2	0.6364	0.883	0.6395	0.9441

Note: Standard errors in the parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

On the other hand, when it comes to medium- to small-sized old office buildings, there are fewer attractive elements that lead to differentiation for tenants. In this case, a green label shows that the office building is of comparatively good value. In this market, office buildings with a green label have always been rare, and thus, stand out. However, over time, obtaining a green label would not be sufficient to regain competitiveness. In such cases, perhaps it would be necessary to consider drastic measures such as rebuilding or renovating such buildings.

4.5 Estimating the hedonic model considering the characteristics of tenants

After clustering according to the propensity score, even in those clusters with environmental certifications, as well as pair data analysis matching the same number due to the propensity scores, we learn there is a premium of about 12%. However, we cannot conclude from these results that environmental certification is related to the premium. In Fuerst and Shimizu (2016), the results of considering the attributes of home buyers in the housing market in Tokyo revealed that more high-income earners paid expensive premiums for environmental certification. Eichholtz et al. (2009) also pointed out that among the corporations that have office buildings with environmental certifications, many are retailers with direct contact with consumers, the government related agencies, or energy-related corporations. If the attributes that position the office buildings for environmental certification were to change due to tenant characteristics, the economic premium for the environmental certification would also change due to differences in those attributes. In that case, the economic premium estimated without considering tenant characteristics would be overestimated.

Here, regarding cluster 4, which had the largest influence on how the existence of an environmental certification affects new rental agreements, an analysis was conducted by expanding this model and including the attributes of current tenants. The attributes of tenants were gathered by collecting information on current tenants in 60 properties in cluster 4 according to the tendency score matching (30 with environmental certification and 30 without).[6] The result was 299 tenants (124 tenants with environmental certification and 175 tenants without) identified as tenants occupying office floors. When these tenants were matched with the corporate information of Tokyo Shoko Research (TSR), which collects corporate and financial information representative of Japan, we were able to obtain corporate and financial information for 50 corporations with environmental certification and 60 corporations without it.

In Table 7, the companies are separated into the environmentally certified group (certified) and the non-certified group (non-certified). In addition to quantitative data, such as financials, TSR[7] also looks at scores created by adding the management quantitative data and various distribution of capital, number of employees, mean value

[6] The data source is Zenrin Co., Ltd. Zenrin investigated the names of the tenants on each floor of each of the buildings they visited. They conducted the research once every three months in the Tokyo region.

[7] The TSR score is created by combining financial data such as capital, sales, number of employees, and revenue. It also takes into consideration attributes such as social credibility, which cannot be measured by management's qualitative attributes and financial information. Ono and Uesugi (2006) applied the TSR score to prioritize transactions from financial institutions.

of sales, standard deviation, and verification of the difference in means (p-value), which are shown in Figure 1.

Table 7 Summary statistics on corporations

	Certified	Non-Certified	p-value
Score	59.04	56.683	0.079
	-6.907	-6.961	
Capital	14,767,295	20,608,054	0.744
	-51,890,634	-124,465,592	
Number of employees	3186.26	950.41	0.187
	-11,630.61	-2,392.09	
Sales	205,545,491	115,977,306	0.515
	-805,873,579	-585,563,697	
Number of observations	50	60	

As can be understood from the test statistics of the difference in mean value and shown in Figure 1, though there is no difference in capital, number of employees, or sales between the corporate groups in environmentally certified buildings and those in non-certified buildings, there was some difference at the 7% significance level according to the TSR score.

Eichholtz et al. (2009) focused on the industry differences among tenants occupying environmentally certified and non-certified office buildings. Here, we examined the ratio of those industries (Figure 2). In manufacturing, the score was 15.1% for the certified group, around 2.5 times as much as for the non-certified group (6.1%). In the wholesale and retail trade, the score was 30.2% for the certified group, nearly double the non-certified group's, which had a score of 16.4%. On the other hand, in information and communications, the score was 9.4% for the certified group, representing a significant difference compared to the non-certified group, which had a score of 24.6%. However, it was difficult to conclude that there was an overall significant deviation by industry between the environmentally certified and non-certified groups.

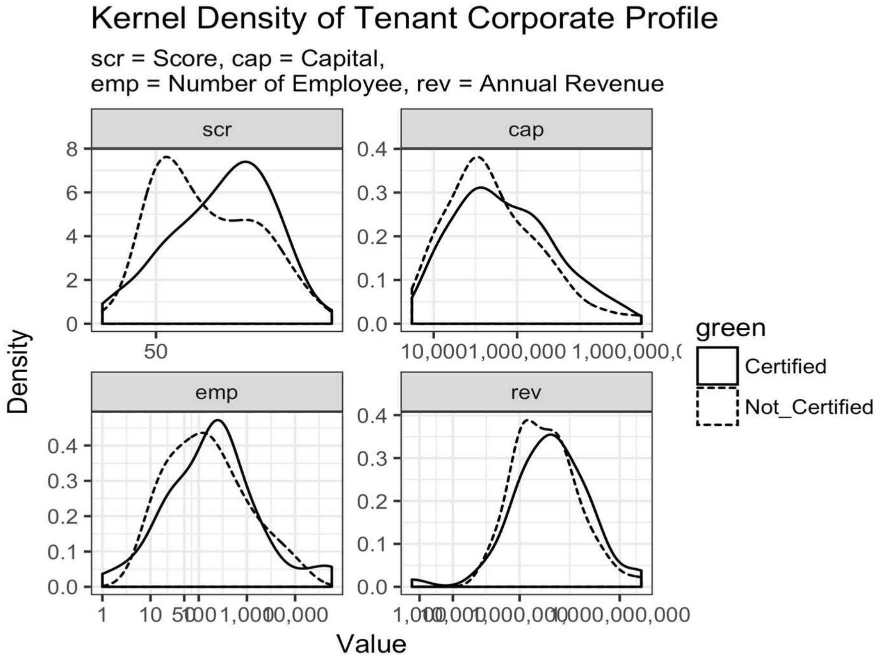

Figure 1. Distribution difference in corporate data

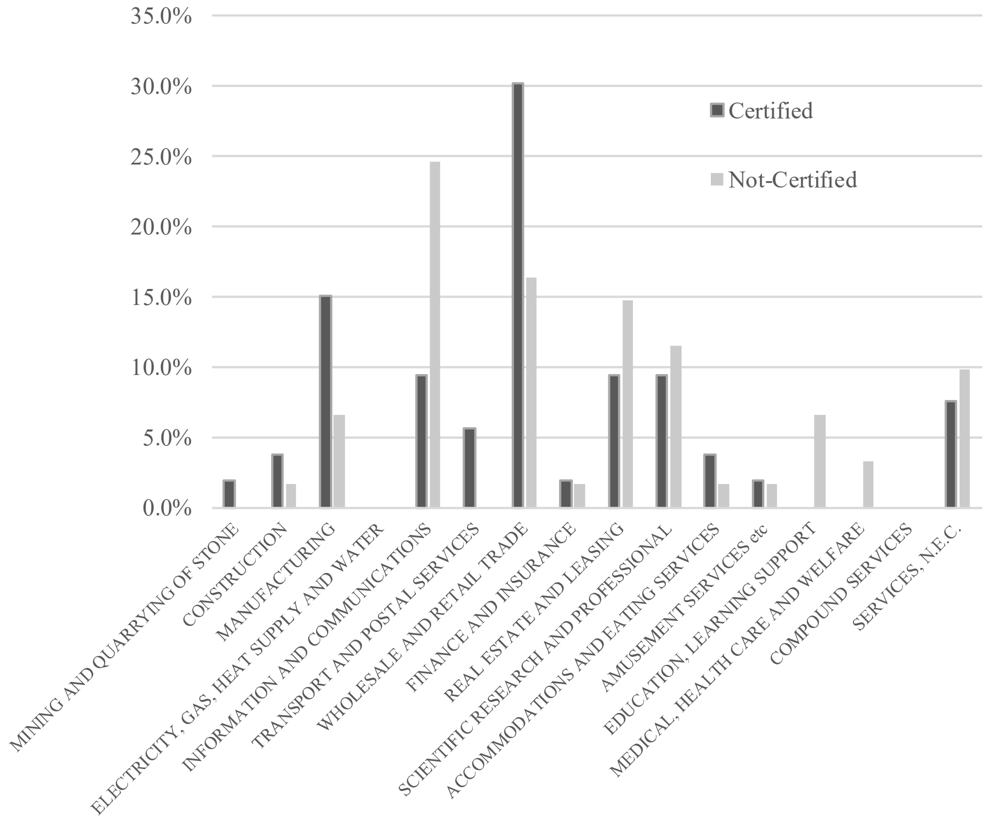

Figure 2. Probability of certification by industry

Therefore, we made estimates in a model that considers a significantly higher standard of difference, depending on the existence of environmental certification.[8] The estimated results are shown in Table 5, Column (4). The premiums from environmental certification were 12.9% in model (2), but when considering the TSR score, we found that the result dropped to 5.6% and was not significant. In other words, this means that the probability of office buildings with environmental certification being selected by more economically viable corporations was relatively high, which makes it seem as though they are paying a high premium.

This provides a very important indication. In a study by Yoshida et al. (2016), it was suggested that the economic premiums for green labels disappear once power and water bills are taken into consideration. If we draw a conclusion from our estimates, in Japan, the green label does carry an economic value but this should not be attributed to the effect of the green certification. The economic value is created because users with a strong sense of responsibility choose buildings that meet high, green building standards. As a more detailed interpretation, it can be said that the economic value of office buildings with a green label is created in the following way.

A company with a high TSR score is an excellent enterprise that has a management team with high social esteem, from the qualitative aspect, and with high operational efficiency and stable financial health, from a quantitative aspect. Such an enterprise has a strong sense of social responsibility, and thereby, will most likely choose a building with green certification and has a higher willingness-to-pay for it. Furthermore, as this kind of company utilizes natural resources efficiently, it can be interpreted that it is paying higher rent compared to the market price because it believes that its gain from energy savings will exceed the higher rent. After we control for this selection effect, the rent premium for green label disappears.

5. Conclusion

This study empirically estimates the rent premium for green office buildings in Tokyo, where office buildings utilizing advanced environmental technology have been recently developed. We analyze the economic premium attributable to the presence or absence of

[8] There were 34 properties included in the rent information cluster 4 (environmentally certified: 10 properties, non-certification: 24 properties). The tenant attributes were revealed for 28 of those properties (environmentally certified: 8 properties, non-certification: 20 properties). For this score, the median (median score for the tenants currently residing in the building for which corporate information was available) was used to represent the tenant attributes in each building unit. Additionally, in Table 5 (2), we compared the rent of 30 environmentally certified buildings and 30 buildings with no environmental certification, but we were only able to match 25 buildings with environmental certification and 26 buildings with no environmental certification to the TSR data, reducing each group by about five properties.

a green label among a sample of 6,758 office buildings in Tokyo. The findings are summarized as follows:

- After performing a quality adjustment of building characteristics with the hedonic approach, green labels showed a significant effect, +4.39% on new rent contracts in our OLS regression.
- By estimating the propensity score for the target variable of the presence or absence of a green label, we confirm that the building characteristics of age and size make it easier to obtain a green label. To address endogeneity, we use samples that are adjusted, using the nearest neighbor matching technique, based on propensity scores. In this case, the effect of a green label was not statistically significant.
- When we analyze the samples clustered according to the value of the propensity score, we find that the effect on the stratum in which large and new buildings are concentrated is not statistically significant. Furthermore, the effect on the stratum in which medium-sized and older buildings are concentrated is +13.78% and statistically significant.
- By conducting further propensity score matching on the clustered samples, we are able to verify the robustness of our analysis results. In addition, we find that even in the mid-sized market, where green labels make a difference in the rent contract, buildings that are 30 years or older are no longer affected by these labels.
- When considering tenant attributes, we find that companies with higher TSR scores (indicating that they have high operational efficiency, stable financial health, and strong social responsibility) are more likely to move to green office buildings and they also have a higher willingness-to-pay for the green label as the gain from energy savings means more to them. After we control for this selection effect, the rent premium for green label disappears.

This series of empirical results provide some implications regarding green certification in the real estate market. It has been empirically shown that the economic value of a green label itself is not very prominent. On the other hand, in the case of older office buildings, green certification seems to be a factor differentiating them from other buildings with low sustainability, thereby creating economic value.

However, the green label can send a clear signal to the market and companies with a strong sense of social responsibility are more likely to choose a building with a green label, and also are willing to pay higher rents for green buildings. This triggers firm sorting along this green dimension.

References

Banfi, S., Farsi, M., Filippini, M., Jakob, M., 2005. Willingness to pay for energy-saving measures in residential buildings. CEPE Working Paper 41.

Brounen, D., Kok, N., 2011. On the economics of energy labels in the housing market. J. Environ. Econ. Manage. 62, 166–179.

Deng, Y., Li, Z., Quigley, J.M., 2012. Economic returns to energy-efficient investments in the housing market: Evidence from Singapore. Reg. Sci. Urban. Econ. 42 (3), 506–515.

Deng, Y and J. Wu., 2014. Economic Returns to Residential Green Building Investment: The Developers' Perspective, Reg. Sci. Urban Econ. 47, 35-44.

Ekeland, I., J. J. Heckman and L. Nesheim, 2004, "Identification and Estimation of Hedonic Models," J.Pol. Econ., 112, pp.60-109.

Eichholtz, P. Kok, N., Quigley, J., 2009. Why do companies rent green? Real property and corporate social responsibility. Program on Housing and Urban Policy Working Paper W09-004.

Eichholtz, P., Kok, N., Quigley, J., 2010. Doing well by doing good? Green office buildings. Am. Econ. Rev. 100, 2492–2509.

Eichholtz, P., Quigley, J. 2012., Green building finance and investments: Practice, policy and research. Eur. Econ. Rev. 56 (5), 903–904.

Fuerst, F., McAllister, P. 2011., Eco-labelling in commercial office markets: Do LEED and Energy Star offices obtain multiple premiums? Ecol. Econ. 70, 1220–1230.

Fuerst, F., McAllister, P., Nanda, A., Wyatt, P., 2015. Does energy efficiency matter to home-buyers? An investigation of EPC ratings and transaction prices in England. Energy Econ., 48, 145–156.

Fuerst, F., Shimizu C., 2016. The rise of eco-labels in the Japanese housing market. J. Jap. Int. Econ. 39, 108–122.

Hyland, M., Lyons, R.C., Lyons, S., 2013. The value of domestic building energy efficiency—Evidence from Ireland. Energy Econ. 40, 943–952.

Kahn, M.E., Kok, N., 2014. The capitalisation of green labels in the California housing market. Reg. Sci. Urban Econ. 47, 25–34.

Miller, N., Spivey, J., Florance, A., 2008. Does green pay off? J. Real Estate Portfolio Manage. 14, 385–399.

Ono, A., Uesugi, I., 2006. Role of collateral and personal guarantees in relationship lending: Evidence from Japan's SME loan market. J. Money Credit Bank. 41(5), 935–960.

Reichardt, A., Fuerst, F., Rottke, N., Zietz, J., 2012. The business case of sustainable building certification: A panel data approach. J. Real Estate Res. 34, 99–126.

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

Shimizu, C., 2013. Sustainable measures and economic value in green housing, Open House Int. J. 38(3), 57–63.

Yoshida, J., Sugiura, A., 2015. The effects of multiple green factors on condominium prices. J. Real Estate Fin. Econ. 50(3), 412–437.

Yoshida, J., J. Onishi, and C. Shimizu, (2016), Energy Efficiency and Green Building Markets in Japan. SSRN: 2844040.

Zheng, S., Wu, J., Kahn, M., 2008. Land and residential property markets in a booming economy: New evidence from Beijing. J. Urban Econ. 63, 743–757.

Zheng, S., Wu, J., Kahn, M.E., Deng, Y., 2012. The nascent market for "green" real estate in Beijing. Eur. Econ. Rev. 56(5), 974–984.