An Investigation of the Effect of Eco-Labeling on Office Occupancy Rates

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Abstract This paper investigates the effect of eco-labeling on the occupancy rates of commercial offices in the United States. The occupancy rates of LEED and ENERGY STAR-labeled offices are compared to a sample of non-labeled offices. Using OLS and quantile regression analyses, a significant positive relationship is found between occupancy rate and the eco-label. Controlling for differences in age, height, building class, and quality, the results suggest that occupancy rates are approximately 8% higher in LEED-labeled offices and 3% higher in ENERGY STAR-labeled offices. However, for ENERGY STAR-labeled offices, effects are concentrated in certain market segments.

In the real estate sector, eco-labeling has been one of the most important elements of a blend of governmental policies used to encourage market participants to voluntarily improve the environmental performance of the commercial building stock. In many real estate markets it is possible to observe a range of policy options being implemented at the local and national level to encourage this trend. Policies include increasing mandatory minimum standards, offering fiscal incentives, using 'positive discrimination' procurement, and improving information dissemination. A key signal of a building's environmental performance has been eco-labels provided by independent, albeit sometimes government-sponsored, third-party organizations. While there is a growing body of work investigating whether eco-labeled offices display evidence of rental and price premiums, this paper focuses on the effect of eco-labeling on occupancy levels.

This paper provides an empirical investigation of occupancy rate differentials between Leadership in Energy and Environmental Design (LEED) and ENERGY STAR-labeled offices and non-labeled commercial offices in the United States. In the analysis, eco-labeled offices are compared to a sample of non-labeled offices, which were selected to include properties in the same submarket areas as the labeled sample. Occupancy is related to a set of hedonic characteristics of the buildings such as age, location, number of stories, inter alia. Essentially, our hedonic model measures occupancy rate differences between labeled offices and randomly selected non-labeled offices in the same submarkets controlling for differences in lease contract, age, height, quality, sub-market, etc. We first estimate occupancy rate regressions for a sample of approximately 292 LEED and 1,291 ENERGY STAR-labeled buildings (the precise number varies slightly with model specification), as well as approximately 10,000 offices in the control group. Using OLS and quantile regression analyses, a significant positive relationship is found between occupancy rate and the eco-label. Controlling for differences in age, height, building class, and quality, the results suggest that occupancy rates are 8% higher in LEED-labeled offices and 3% higher in ENERGY STAR-labeled offices. However, for ENERGY STAR-labeled offices, the effects are concentrated in certain market segments.

The remainder of this paper is organized as follows. The first section provides a background discussion of the topic focusing on the growth in environmental certification, the nature of eco-labeled offices, and previous research on their costs and benefits. The main empirical section outlines the data and methods used in the study followed by a discussion of the results. Finally, conclusions are drawn.

Background and Context

Eco-labeling in Commercial Real Estate Markets

Certification and labeling codes are usually part of a policy to increase the supply of environmental public goods (Kotchen, 2006). The mechanism is to alter the behavior of users by providing more information about the environmental performance of alternative products and services. The aims are to encourage a shift towards more environmentally responsible consumption and to encourage producers to enhance the environmental performance of products and services. It is envisaged that better information, increased market transparency, and the consequent price outcomes will produce superior environmental performance. A benefit of voluntary eco-labeling is that the market prices of products with superior environmental performance are revealed. As a result, potential inefficiencies associated with mandatory standards or complete prohibition are avoided.

A blend of voluntary and mandatory eco-labels has emerged in a number of commercial real estate markets. Voluntary environmental certification systems for buildings include schemes such as Green Star (Australia), LEED (U.S.), ENERGY STAR (U.S.), Green Globes (U.S.), and BREEAM (U.K.). Mandatory certification of energy efficiency was introduced in the European Union in 2008 following the EU Energy Performance of Buildings Directive and takes the form of Energy Performance Certificates and Display Energy Certificates. This paper focuses on two U.S. voluntary eco-labeling schemes: the Environmental Protection Agency's ENERGY STAR and the U.S. Green Building Council's Leadership LEED programs.

Office properties tend to dominate both the LEED and ENERGY STAR-accredited buildings in terms of space and numbers (Nelson, 2007). The ENERGY STAR program is used more for existing buildings. It is linked to an assessment of buildings' energy performance. ENERGY STAR accreditation is based upon relative energy efficiency and environmental performance since only buildings that are in the top quartile are eligible for ENERGY STAR accreditation. LEED accreditation is based upon scores in a number of different categories focused on sustainability of location, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and design processes. The LEED thresholds are primarily absolute. Buildings that reach the required levels are labeled. There are four levels of certification: Certified, Silver, Gold, and Platinum. LEED certification is comparable to other eco-certification schemes in the United Kingdom, Germany, and Australia and is likely to provide the framework for prospective harmonized global standards. Given their differences, it is not surprising that studies have found important differences between ENERGY STAR and LEED-labeled buildings in terms of average size, age, height, and other variables.

While the presence of an eco-label and good environmental performance are not necessarily synonymous, there is a substantial body of literature suggesting that environmentally responsible buildings offer a bundle of benefits to occupiers and investors. Surveys of willingness-to-pay have identified occupiers who have stated that they are prepared to pay higher rents for eco-labeled buildings (e.g., McGraw Hill Construction, 2006; GVA Grimley, 2007; and National Real Estate Investor, 2007). Many states in the U.S. now offer subsidies and tax benefits for eco-labeled buildings. Occupiers benefit from costs savings due to lower energy and water usage. Less tangibly, since it is difficult to measure, it is argued that business performance may improve in environmentally responsible buildings due to reduced staff turnover, lower absenteeism, *inter alia*. In addition, the rapid increase in allocation of corporate resources to environmental, social, and governance (ESG) issues allied with professed commitments to Corporate Social Responsibility (CSR) has created potential marketing and image benefits for occupying and investing in buildings labeled as environmentally responsible. Central to this paper is the possibility that, in turn, investors may also obtain a bundle of benefits linked to lower vacancy rates, rental premiums, lower energy and other utility costs, reduced depreciation, and reduced regulatory risks.

There have been a number of studies of the construction cost premium associated with achieving certification (e.g., Kats, 2003; Morrison Hershfield, 2005; and Berry, 2007). These studies suggest small construction cost premiums of around 2% on average. The most recent and authoritative studies have come from Davis Langdon (a global construction consultancy). Their most recent study compared 83 building projects with a primary goal of LEED certification with 138 similar building projects without the goal of sustainable design (Matthiessen and Morris, 2006). Confirming the findings of earlier studies, they found no significant difference in average costs for building projects with a primary goal of LEED certification as compared to non-labeled buildings.

As noted above, there have been a number of studies measuring the price effects of eco-certification on commercial offices. To date, most of the studies have used the CoStar database to compare the sale prices and/or rents of LEED and ENERGY STAR buildings in the U.S. These studies are summarized in Exhibit 1.

Exhibit 1 | Summary of Studies of LEED and ENERGY STAR Buildings Using CoStar Data

Study	Data	Approach	Findings on Price Differentials	Other Findings
Miller, Spivey, and Florance (2008)	Filtered sample of Class A buildings (larger than 200,000 sq ft, multi-tenanted, over five stories, built after 1970) to compare to 643 ES buildings. 927 sale transactions between 2003 and 2007. Breakdown between LEED and ES sale price observations is unclear.	Hedonic OLS regression for sale prices only. Controls for major markets but none for quality.	Finds no statistically significant sales price premium.	Occupancy rate is 2%–4% higher for ES compared to non-ES filtered sample. Report 30% lower operating expenses based on energy costs.
Wiley, Benefield, and Johnson (2008)	Class A office buildings only. 46 metropolitan markets (25 markets for sales). Breakdown between LEED and ES is unclear. We estimate 30 LEED and 440 ES rental observations and 12 LEED and 70 ES sales observations.	Hedonic OLS and 2SLS regressions for rental and occupancy rates. Control sample seems to be other offices in same metropolitan area. No controls for micro-location effects.	Hedonic OLS and 2SLS find rental differentials of 15%–17% for LEED and 7–9% for ES. Hedonic OLS model of sales prices in absolute form. Estimate sale price premiums of $130 psf and $30 psf for LEED and ES.	Hedonic OLS and 2SLS with occupancy rate as dependent variable finds occupancy rate differentials of 16%–18% for LEED and 10%–11% for ES compared to control group.
Eichholtz, Kok, and Quigley (2009)	Contract rents for 694 certified offices. Sale prices for 199 certified offices 2004–7. Breakdown between LEED and ES is unclear.	Hedonic OLS regressions for rental and sales prices. Control sample is offices within 0.25 miles of certified building.	No statistically significant rental premium for LEED; 3% rental premium for ENERGY STAR. No statistically significant sale price premium for LEED. 19% sale price premium for ENERGY STAR.	Find a positive relationship between energy efficiency measure and level of rental premium.
Fuerst and McAllister (2009)	Asking rents for 990 ES and 210 LEED certified offices. Sale prices for 662 ES and 139 LEED certified offices 1999–2009.	Hedonic OLS regressions for rental and sales prices. Control sample is based on offices within same CoStar submarkets.	6% rental premium for ES and LEED certified offices. 35% and 31% price premium for LEED and ES.	

Nelson (2007) examined the performance differences between labeled and non-labeled buildings using a number of criteria. Drawing upon the CoStar database, the study compared LEED-rated offices and ENERGY STAR offices with a vastly larger sample of non-labeled offices in the CoStar database. While acknowledging the significant differences between the sample and the wider population, it found that labeled buildings tended to be newer, owner-occupied or single tenanted, concentrated geographically and sectorally (in the office sector). Recognizing that it did not control for these differences, the study identified lower vacancy rates and higher rents in LEED-rated offices. To control for differences between their sample of labeled buildings (927 buildings) and a much larger sample of non-labeled buildings, Miller, Spivey, and Florance (2008) include a number of control variables such as size, location, and age in their hedonic regression framework. They find that dummy variables for ENERGY STAR and LEED ratings show the expected positive sign but tests show that these results are not significant at the 10% level. Wiley, Benefield, and Johnson (2008) focused on the effect on rent, occupancy rate, and sale price of eco-certification for Class A office buildings in 46 metropolitan markets across the U.S. They found rental premiums ranging from approximately 15% to 18% for LEED-labeled offices and 7%–9% for ENERGY STAR-labeled offices depending on the model specification. In terms of sales transactions, they estimated premiums of $130/sq. ft. for LEED-labeled offices and $30 for ENERGY STAR. However, although plausible, these results need to be treated with some caution. A limitation of their hedonic model is their control for location. In essence, they identify rental and sale premiums for labeled offices relative to non-labeled offices *in the same metropolitan area*. However, if labeled offices tend to be more likely to be found in better quality locations within a metropolitan area, observed premiums may include a location as well as a certification premium.

In a working paper, Eichholtz, Kok, and Quigley (2009) also used a hedonic framework to test for the effect of certification on the contract rents of 694 office buildings. Using GIS techniques, they control for location effects by identifying other office buildings in the CoStar database within a radius of 0.25 miles of each labeled building. They identify a statistically significant rent premium (3%) on the contract rents per square foot of ENERGY STAR-labeled offices. They find no significant rent premium for LEED-labeled offices. However, when they used ''effective'' rents to reflect different vacancy rates in labeled offices, the premium increased to around 10% for ENERGY STAR-labeled offices and 9% for LEED-labeled offices.[1] Similar results were found for transaction prices. Although not discussed in the paper, they found a substantial 19% sale price premium for ENERGY STAR-labeled offices but no statistically significant premium for LEED-labeled offices.

Within the real estate sector, occupancy (or vacancy) rates are commonly used as a *portmanteau* indicator of market conditions. Vacancies can impose substantial costs upon investors. In addition to the loss of income, investors incur a number of fixed and variable costs. These will include brokerage and legal fees associated with finding a new occupier and CAM-related expenses (maintenance, security, utilities, insurance, local real estate taxes, etc). In addition, variations in vacancy rates among buildings in similar locations may be attributable to differences in demand which, in turn, may be attributable to the characteristics of the buildings. The vast majority of the academic literature on vacancy levels has been on modeling regional or metropolitan levels; typically focusing on their explanatory power in rent determination at the market level. Not surprisingly, these studies have tended to find a positive relationship between rent and occupancy rates. Essentially both rent and occupancy rates are analyzed as jointly determined and are modeled as outcomes of the interaction of the same supply and demand conditions.

In addition, there is a much smaller body of work drawing upon search theory that analyses the micro-foundations of rent and vacancy determination. An important insight is that, at the building level, vacancy rates consist of both voluntary and involuntary components. The voluntary component is part of a strategic trade-off by the owner in an attempt to identify equilibrium vacancy and rental levels. In this context, it is possible that, due to enhanced problems of noisy price information, eco-labeled offices present additional price setting problems for their owners. Although owners of eco-labeled offices are aware that occupiers will obtain an additional consumer surplus relative to non-labeled offices, information about the reservation prices of occupiers may be costly or difficult to obtain due to the relative novelty of the product. Following search theory, if the expected distribution of rental offers is higher for eco-labeled offices, there is an additional incentive to continue searching for occupiers (i.e., to keep space vacant). By searching longer, the owner is able to learn more about the range of offers available. Thus, the rational vacancy rate may be higher for eco-labeled offices.

There has been some empirical investigation of the strategic issues faced by owners and the simultaneous determination of rents and occupancy rates. Frew and Jud (1988) investigated the interaction between vacancy rates and rents at the individual building level. They essentially tested the hypothesis that ''landlords who are willing to accept higher average vacancy rates, thus, will tend to have higher than average rents at any point in time,'' (p. 3). They also postulate that there should be a negative relationship between building age and vacancy rate since they expect managers of new offices to trade off vacancy levels with the price discovery of the marketing process. In their empirical investigation, they analyze data from a single office market using a hedonic regression approach. In common with Sirmans, Sirmans, and Benjamin (1990), they find evidence of a positive relationship between vacancy and rent. In addition, they also found a negative relationship between age and vacancy.

In terms of this research, there are a number of other studies investigating differences in occupancy/vacancy rates between LEED and ENERGY STAR-labeled offices. In addition to examining the effects of certification on rents and sale prices, Wiley, Benefield, and Johnson (2008) also modeled occupancy rates. Using a similar approach to the pricing study discussed above, they find that LEED and ENERGY STAR-rated offices have occupancy rate premiums of 16%–18% and 10%–11%, respectively. They also report a positive relationship between rent and occupancy rate. However, as noted, this study did not control for potential micro-location effects. Drawing upon the CoStar database also, Miller, Spivey, and Florance (2008) compared a filtered sample of Class A offices with ENERGY STAR-rated offices. Looking at the period 2004–2008, they find a much lower occupancy rate premium ranging between 2% and 5%. Nelson (2007) also finds that eco-labeled buildings have lower vacancy rates relative to the total CoStar universe.

In summary, since they provide a range of tangible and intangible benefits to occupiers, there are strong a priori grounds to expect eco-labeled offices to have lower vacancy rates than comparable non-labeled offices. There are also strong grounds to expect levels of occupancy differential to vary cross-sectionally. LEED and ENERGY STAR ratings are significantly different and tend to be associated with different market segments. Within LEED, there are different levels of certification. As a result, there are likely to be variations between labeled offices in the levels of the potential benefits (reduced costs of occupancy, image, and business performance) that may be obtained by occupiers.

Empirical Research

Method and Data

When attempting to measure differentials between a labeled and non-labeled product, the key methodological issue is to identify an appropriate benchmark to compare labeled and non-labeled products. In some product markets, apart from the certification label, eco-friendly goods may be indistinguishable from conventional goods (e.g., some timber or food commodities). As a result, it is often straightforward to identify a suitable benchmark against which to measure a differential. In contrast, in markets where products are bespoke (such as commercial real estate), the construction and design requirements of obtaining certification may add to inherent product heterogeneity. Thin trading and low market transparency may reduce the amount and quality of available information. The result is that measuring the differential for eco-labeled offices is hindered by the combination of a lack of an appropriate benchmark and limited information due to thin market effects.

Hedonic regression modeling is the standard methodology for examining price determinants in real estate research. This method is used here primarily to measure the effect of LEED and ENERGY STAR certification on occupancy rates. Rosen (1974) first generalized that the hedonic price function covering any good or service consisted of a variety of utility-bearing characteristics. In the office rent determination literature, hedonic modeling typically specifies that a range of physical, locational, and lease characteristics be used as the independent variables determining price. In this study, occupancy rate is specified as the dependent variable. For the purpose of this study, we specify two types of hedonic models: OLS and quantile regression.

Hedonic Model

The OLS regression model of building occupancy rates takes the following form:

$$OR_i = \beta_0 + \beta_1 \ln A_i + \beta_2 \ln N_i + \beta_2 \ln S_i + \beta_3 \ln L_i + \beta_4 \ln T_i + \beta_5 \ln G_i + \beta_6 InR_i + \beta_7 BC_i + \beta_8 SU_i + \beta_9 LD_i + \beta_{10} ES_i + \varepsilon_i. \quad (1)$$

In this model, A_i represents the age of the property, measured from the year of construction or the year of a major refurbishment (whichever occurred more recently); N_i indicates a net lease with a value of 1 and a gross lease with a value of 0; S_i is the number of stories of the property; L_i represents the lot size; T_i and G_i are the latitude and longitude geographic coordinates of the property, which capture any large-scale effects of the spatial distribution of properties across the country; R_i represents the asking rent; BC_i are controls for building class (standard categories A, B, C, and F); SU_i are controls for submarkets; and ε_i is the error term, which is assumed to be independent across observations and normally distributed, with constant variance and a mean of zero. A rent premium for LEED and/or ENERGY STAR-rated offices is captured by the LD_i and ES_i terms, a dichotomous variable that takes the value of 1 for labeled offices and a value of 0 otherwise.

Details of LEED and ENERGY STAR offices were obtained from the CoStar database. Given the discussion above, a key issue is the benchmark against which the sample of labeled offices can be compared. Our benchmark sample consists of approximately 24,479 office buildings in 643 submarkets in 81 metropolitan areas spread throughout the U.S. In effect, the hedonic model is measuring occupancy rate differences between eco-labeled offices and randomly selected non-labeled offices in the same sub-market area, controlling for differences in age, size, height, building class, and submarket.

In the first step, we drew details of approximately 2,147 eco-labeled offices, of which 667 were LEED-labeled and 1,480 were ENERGY STAR. In the second step, offices were selected in the same metropolitan areas and submarket as the labeled sample. Sample selection was based on the criteria a) same submarket or market as labeled offices and b) at least 10 comparable observations for each labeled building in the database. Although the market weightings may be different between the benchmark and the labeled samples, our regression model controls for market-specific effects.

A key consideration in measuring the effect of eco-certification on occupancy rates is that the different types of certification (LEED, ENERGY STAR, and non-labeled) have variations in their propensity to be leased to a single tenant. Since single-tenanted offices are typically 100% occupied, their inclusion may introduce a bias if they are not represented in the eco-labeled and the control samples in equal proportions. For instance, the data suggests that ENERGY STAR-rated offices tend to be multi-tenanted compared to non-ENERGY STAR offices. We estimate that approximately 30% of the CoStar office database is single tenanted. The corresponding figures for ENERGY STAR and LEED-labeled offices are 9% and 40%, respectively. Although we do not have information on the number of tenants for each property in the dataset, the potential bias can be indirectly eliminated by including only those properties with positive rent observations. A simple count of properties in the CoStar database reveals that asking rents are only available for a small fraction (approximately 0.5%) of single-tenanted LEED buildings.

Our second approach involves the application of a quantile regression approach. Quantile regression is typically used to assess whether there is an unequal variation in the response of the dependent variable to the independent variables. Such unequal variation is associated with the presence of multiple relationships between the independent and dependent variables. In this instance, the quantile regression is providing a method of examining whether the effect of eco-labeling is more important in certain segments of the market.

Following Koenker and Hallock (2001) and Koenker (2005), the abbreviated specification of our quantile regression model for occupancy rates reads:

$$OR_i = \beta_\tau X_i + \mu_{\theta i} \text{ with } Quant_\tau(OR_i) = \beta_\tau X_i, \qquad (2)$$

where X_i denotes the vector of regressors and β_τ is the vector of estimated parameters. $Quant_\tau(Or_i) = \beta_\tau X_i$ is the τth conditional quantile of OR_i given the vector of variables X. The τth quantile regression is then estimated by:

$$\min_{\beta \in \Re^p} \left\{ \sum_{i:OR_i \geq \beta X_i} \tau |OR_i - \beta_\tau X_i| + \sum_{i:OR_i < \beta X_i} (1 - \tau)|OR_i - \beta_\tau X_i| \right\}, \qquad (3)$$

which can also be expressed as:

$$\min \sum_i \rho_\tau(OR_i - \beta_\tau X_i),$$

where $\rho_\tau(\varepsilon)$ is the check function that weights positive and negative values asymmetrically, and $\rho_\tau(\varepsilon) = \tau\varepsilon$ if $\varepsilon \geq 0$ or $\rho_\tau(\varepsilon) = (\tau - 1)\varepsilon$ if $\varepsilon < 0$.[2] This yields estimates for the specified quantiles (i.e., deciles in our empirical estimation).

Results

Descriptive statistics of the variables included in the model are displayed in Exhibit 2. There are major differences between eco-labeled and non-labeled offices and, in turn, between LEED and ENERGY STAR-labeled offices. LEED-labeled offices tend to be newer. The median age of LEED-labeled offices is five years. The comparable figure for the benchmark sample is 23 and for ENERGY STAR offices it is approximately 20. While there is relatively little difference between offices with ENERGY STAR certification and the benchmark sample in terms of age, the former tend to be dominated by tall buildings suggesting that they are mainly located in high value CBD locations. This is supported by the fact that ENERGY STAR offices tend to be on average much larger than non-labeled offices. Without controlling for the differences between the samples, eco-labeled offices have higher asking rents and lower vacancy rates than non-labeled offices. It is notable that the median occupancy rate for LEED is 100%. This is not solely due to the fact that 40% of LEED-labeled office buildings are single tenanted

Exhibit 2 | Summary Statistics

Overall	Occupancy Rate (%)	Rent ($ psf)	Age (years)	Size (sq. ft.)	Stories
Mean	63.07	19.50	28.35	52,771	3.32
Median	78.63	18.00	23.00	10,800	2.00
Std. Dev.	38.95	9.16	27.45	145,147	5.80
Obs.	24,283	16,488	21,137	24,951	24,480
ENERGY STAR					
Mean	91.42	27.76	19.44	315,051	13.40
Median	95.76	25.04	20.00	217,082	9.00
Std. Dev.	12.44	11.37	12.76	301,264	12.89
Obs.	1,480	990	1,474	986	1,453
ES Multi-tenant					
Mean	90.30	27.80	19.10	328,135	14.45
Median	94.17	25.11	20.00	228,883	10.00
Std. Dev.	12.60	11.38	11.14	303,331	13.20
Obs.	1,291	1,291	985	1,291	1,291
LEED					
Mean	91.07	26.74	11.77	179,290	6.45
Median	100.00	24.50	5.00	95,000	4.00
Std. Dev.	22.46	11.00	19.06	262,071	8.50
Obs.	667	210	504	667	622
LEED Multi-tenant					
Mean	83.69	27.55	11.06	229,319	8.85
Median	99.00	25.92	4.00	127,690	5.00
Std. Dev.	27.74	10.74	18.32	320,370	10.47
Obs.	292	169	264	292	292

since the median occupancy rate for multi-tenanted LEED offices is 99%. The median occupancy rate for ENERGY STAR is over 95%. There is little difference in the occupancy rates of single-tenanted and multi-tenanted ENERGY STAR offices.

When controlling for the rent determinants such as building class, age, height, size, and sub-market location, we find evidence that eco-labeled office buildings have higher occupancy rates. In the OLS model, there is a statistically significant positive coefficient for the ENERGY STAR and LEED dummies, indicating that

Exhibit 3 | Results of Hedonic Regression

	OLS
Constant	−56.61
Class A	−6.01***
Class B	−1.61**
LEED	7.70***
ENERGY STAR	2.88**
Net Lease	−9.62***
Height	0.35
Size	9.71***
Area	−1.73***
Longitude	−0.51***
Latitude	−40.95**
3–6 years	17.98***
7–10 years	24.20***
11–19 years	20.85***
20–23 years	21.02***
23–26 years	23.27***
27–31 years	21.02***
32–42 years	20.31***
43–62 years	17.21***
>62 years	13.36***
F-test	7.25***
Adj. R^2	0.28

Notes: We do not include rent in this specification of the model due to problems of endogeneity. However, we did estimate the model with asking rent included as an independent variable. The results and explanatory power of the model did not change significantly. There were 10,977 observations. 647 submarket dummies were included.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

offices with these eco-labels have significantly higher occupancy rates than offices with similar attributes in the same sub-market (Exhibit 3). The results suggest an 8% higher occupancy rate for LEED-labeled offices. The occupancy rate premium is approximately 3% for ENERGY STAR-labeled office offices. These findings are similar to Miller, Spivey, and Florance (2008), who find a 2%–4% higher occupancy rate for ENERGY STAR offices.

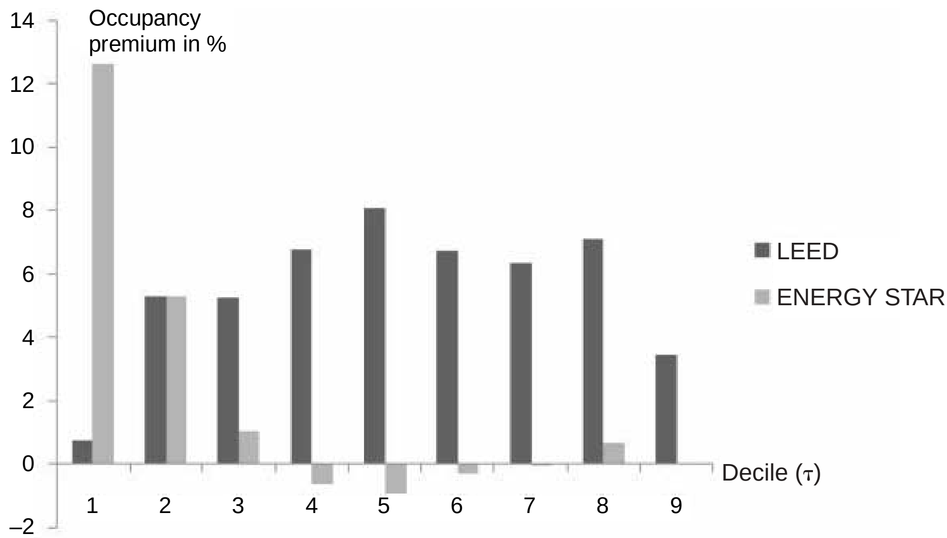
The results for the other variables are in line with expectations. In line with previous research on price premiums in LEED and ENERGY STAR offices and in other studies of office rental determination, occupancy levels (similar to rent levels) display a positive relationship with size. Compared to recently constructed offices (aged 0–3 years), occupancy rates of offices tend to increase as offices get older, stabilizing after ten years. However, the lack of a statistically different occupancy rate differential linked to building quality is notable. The low explanatory power of the models suggests that important variables may have been omitted. It may also be due to the fact that the effects of the independent variables are concentrated in certain categories of the dependent variable. Quantile regression can provide an effective method for obtaining more reliable estimates

Exhibit 4 | Quantile Regression

	Decile (τ)	Coeff.	Pseudo R^2	QLR Statistic (prob. QLR)	Sparsity
LEED	1	0.75	0.20	1,640.6 (0.00)	189.80
	2	5.28	0.32	4,197.7 (0.00)	124.33
	3	5.27*	0.29	4,004.2 (0.00)	107.35
	4	6.75***	0.25	4,049.7 (0.00)	84.62
	5	8.08***	0.21	3,143.6 (0.00)	82.50
	6	6.71***	0.18	2,596.3 (0.00)	76.41
	7	6.38***	0.14	2,010.4 (0.00)	72.88
	8	7.11***	0.11	1,508.7 (0.00)	68.85
	9	3.45***	0.07	1,188.6 (0.00)	52.87
ENERGY STAR	1	12.63***	0.20	1,640.6 (0.00)	189.80
	2	5.31***	0.32	4,197.7 (0.00)	124.33
	3	1.02	0.29	4,004.2 (0.00)	107.35
	4	−0.63	0.25	4,049.7 (0.00)	84.62
	5	−0.94	0.21	3,143.6 (0.00)	82.50
	6	−0.34	0.18	2,596.3 (0.00)	76.41
	7	−0.02	0.14	2,010.4 (0.00)	72.88
	8	0.68	0.11	1,508.7 (0.00)	68.85
	9	0.00	0.07	1,188.6 (0.00)	52.87

Notes:
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

Exhibit 5 | LEED and ENERGY STAR Occupancy Rate Premia by Decile



when the model coefficients vary significantly across the distribution of the dependent variable.

Exhibit 4 displays the results of the quantile regressions for each individual decile for the sample. The results suggest that there are clear differences in the effect of eco-labeling for the different segments. For ENERGY STAR-labeled offices, only statistically significant positive coefficients for this eco-label are identified for the bottom two deciles. For the LEED-labeled offices, we find a different pattern. The quantile regression finds a statistically significant positive relationship between the LEED eco-label and the occupancy rate for all deciles except the bottom two. This is probably due to the fact that relatively few ENERGY STAR buildings are completely vacant and thus command a large occupancy rate premium in the bottom decile of the market. Overall, the results confirm that the magnitude of the premium tends to be larger for LEED buildings, particularly in the upper deciles of occupancy rates.

Conclusion

Eco-labels are used both by businesses and regulators to increase the demand for, and the supply of, environmentally responsible products. Essentially, it is envisioned that by increasing awareness and improving information about the environmental performance of products, market prices will be altered by changes in supply and demand. Similar to other product markets, both mandatory and voluntary eco-labels have become increasingly important in the commercial real estate sector. There are strong a priori grounds to expect differences in occupier demand for eco-labeled offices relative to non-labeled offices. It is generally accepted that there are benefits associated with environmentally responsible offices. Occupiers can gain tangibly from lower utility costs and incentives or subsidies and, perhaps less tangibly, from improvements in business performance and marketing benefits. In addition, from an investor's perspective there are a number of channels by which superior environmental performance can influence the financial performance of the asset. These are mainly associated with higher incomes (rental premiums, higher occupancy levels), costs reductions (lower operating expenditure, lower vacancy rates), and reduced risk premia.

It is clear from the data that eco-labeled offices tend to be different from non-labeled offices. ENERGY STAR offices tend to be large, tall, and located in major metropolitan markets. LEED-labeled offices tend to be more diverse. There are distinct differences from both ENERGY STAR and LEED-labeled offices. In particular, from the perspective of occupancy rates, it is notable that approximately 90% of ENERGY STAR-labeled offices are multi-tenanted. The comparable figures for LEED and non-labeled offices are 60% and 70% respectively. It is particularly striking that the median occupancy rate for multi-tenanted LEED-labeled offices is 99%. Overall, the results suggest there is an occupancy premium of approximately 8% for LEED-labeled offices. The quantile regression finds that the LEED label has a significant positive effect on occupancy level for most deciles of LEED offices. Both regression models also indicate a significant positive relationship between occupancy rate and the ENERGY STAR label. For ENERGY STAR-labeled offices, the occupancy rate premium is lower at 3%. The quantile regression suggests that the ENERGY STAR effect is concentrated on offices that are in the lower deciles by occupancy level. Taking into account age, height, building quality, and rent levels, ENERGY STAR-labeled offices are much less likely to have severe vacancy problems than non-labeled office buildings. However, the results suggest that the ENERGY STAR label has no significant effect for offices with relatively high occupancy rates.

Given the relative novelty of eco-labeling in commercial real estate allied to its recent rapid growth, it is important to bear in mind that empirical studies of this type provide a backward-looking snapshot of market differentials for a specific sample in a specific time period. Given the rate of market growth, data will improve and patterns of supply and demand will change. Further, this study has focused on office properties only. Empirical studies of the retail, industrial, and residential markets may arrive at different results. Furthermore, there is little understanding of the relative contribution of the potential sources of occupancy rate or pricing differentials. What are the key drivers of demand—fiscal benefits and subsidies, improved business performance, image benefits or reduced operating costs? Finally, our study presents a static cross-sectional analysis of occupancy rates. As more detailed data and longer time series of eco-labeled properties become available, it will be possible to model differential occupancy rates in a dynamic fashion, potentially incorporating search theory and strategic considerations in determining optimal occupancy levels under given market conditions.

Endnotes

[1] Eichholtz, Kok, and Quigley (2009) also find that there is a higher relative premium for cheaper locations. However, this is likely to be due to the fact that similar absolute premiums due, for example, to lower energy costs will invariably result in higher relative premiums in less expensive locations.

[2] The specification of our quantile regression model uses the Hall-Sheather bandwidth method and Siddiqui (mean fitted) calculations for computing Ordinary (IID) covariances, which are valid under independent but non-identical sampling. Alternative estimations using the Huber sandwich method for computing covariances did not yield significantly different results for the coefficients in question.

References

Berry, T. Towards A Green Building and Infrastructure Investment Fund: A Review of Challenges and Opportunities. Compass Resource Management, 2007.

Eichholtz, P., N. Kok, and J.M. Quigley. Doing Well by Doing Good? Green Office Buildings. Working paper, Fischer Center for Real Estate and Urban Economics, January, 2009.

Frew, J. and G. Jud. Vacancy Rates in Rent Levels in the Commercial Office Market. *Journal of Real Estate Research*, 1988, 1–8.

GVA Grimley. *Towards Sustainable Offices*. Research Bulletin, Spring, 2007.

Kats, G. The Costs and Financial Benefits of Green Buildings—A Report to California's Sustainable Building Task Force. Capital E, 2003.

Koenker, R. *Quantile Regression*. New York: Cambridge University Press, 2005.

Koenker, R. and K.F. Hallock. Quantile Regression. *Journal of Economic Perspectives*. 2001, 15:4, 143–56.

Kotchen, M. Green Markets and Private Provision of Public Goods. *Journal of Political Economy*, 2006, 114, 816–34.

Matthiessen, L.F. and P. Morris. Cost of Green Revisited. Reexamining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Adoption. Davis Langdon, 2006.

McGraw Hill Construction. Green Building Smart Report, 2006.

Miller, N., J. Spivey, and A. Florance. Does Green Pay Off? *Journal of Real Estate Portfolio Management*, 2008, 14:4, 385–99.

Morrison Hershfield. A Business Case for Green Buildings. Internal Morrison Hershfield Report, 2005.

National Real Estate Investor. Fighting Obsolescence: Green Building Survey, 2008.

Nelson, A. The Greening of U.S. Investment Real Estate—Market Fundamentals, Prospects and Opportunities. RREEF Research Report No. 57, 2007.

Sirmans, G., C.F. Sirmans, and J. Benjamin. Rental Concessions and Property Values. *Journal of Real Estate Research*, 1990, 141–51.

Rosen, S. Hedonic Prices and Explicit Markets: Production Differentiation in Pure Competition. *Journal of Political Economy*, 1974, 82, 34–55.

Wiley, J., J. Benefield, and K. Johnson. Green Design and the Market for Commercial Office Space. *Journal of Real Estate Finance and Economics*, 2008.

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