2017 V00 0: pp. 1–38
DOI: 10.1111/1540-6229.12223
REAL ESTATE
ECONOMICS

On the Value of Environmental Certification in the Commercial Real Estate Market

Rogier Holtermans* and Nils Kok**

A significant part of the global carbon externality stems from the real estate sector. Environmental certification is often hailed as an effective means to resolve the information asymmetry that may prevent markets from effectively pricing the energy performance of buildings. This study analyzes the adoption and financial outcomes of environmentally certified commercial real estate over time. We document that nearly 40% of space in the 30 largest U.S. commercial real estate markets holds some kind of environmental certification in 2014, as compared to less than 5% in 2005. Tracking the rental growth of 26,212 office buildings, we measure the performance of environmentally certified real estate over time. We document that certified office buildings, on average, have slightly higher rental, occupancy and pricing levels, but do not outperform non-certified buildings in rental growth over the 2004–2013 period. Further performance attribution analysis indicates that local climate conditions, local energy prices and the extent of certification lead to significant heterogeneity in market pricing. On aggregate, these findings provide some evidence on the efficiency of the market in the adoption and capitalization of environmental characteristics in the commercial real estate market.

Introduction

It is now common knowledge that the commercial real estate sector is related to significant environmental externalities. For example, commercial real estate consumed 18% of total U.S. energy demand in 2014.[1] Awareness of the importance of energy efficiency in buildings has been created through federal programs such as the Environmental Protection Agency's (EPA) Energy Star,

*University of Southern California, Lusk Center for Real Estate, 650 Childs Way, Los Angeles, CA 90089–0626 or rogierho@usc.edu.
**Maastricht University, School of Business and Economics, P.O. Box 616 6200 MD, Maastricht, The Netherlands or n.kok@maastrichtuniversity.nl.

[1]More specifically, statistics from the U.S. Energy Information Administration indicate that commercial buildings consumed 35% of electricity and 18% of natural gas in 2014. This translates to the emission of 981 million metric tons of carbon dioxide from energy consumption in the commercial building stock.

whereas other voluntary certification programs place further importance on the fact that the commercial real estate sector is a major consumer of water and other natural resources, while also producing significant landfill waste and greenhouse gas emissions. The significant environmental impacts of the built environment have captured the attention of regulators, the public, corporate occupiers and investors, who are increasingly demanding more transparency in the environmental performance of buildings through building certification.

The effects of certification and quality disclosure as tools for information provision have been documented quite extensively. For example, Jin and Leslie (2003) investigate the impact of requiring restaurants to display a hygiene quality grade card. Employing a panel data set from Los Angeles County to estimate the impact of this requirement, the findings show that the overall hygiene scores of restaurants increase after introduction of the legislation, and that consumers are sensitive to changes in hygiene quality. Importantly, the improvement in hygiene quality led to a reduction in foodborne illness in the region. Moreover, the authors conclude that ultimately the differences between voluntary and mandatory disclosure are significant, albeit small in magnitude.[2]

Analogous to hygiene quality grade cards in Los Angeles' restaurants, Bollinger, Leslie and Sorensen (2011) examine the impact of mandatory calorie postings in chain restaurants. The authors document that the average calories per transaction decrease by 6% after introduction of the law in New York City in April 2008. The effect is almost entirely related to food purchases as compared to beverage purchases. Moreover, the effect is persistent throughout the period of observation (from January 2008 to March 2009). The authors conclude that the mandatory calorie postings do not have a significant impact on revenue, on average, although revenue increases by 3% in case of nearby competition.

For the automotive industry, Sexton and Sexton (2014) employ ZIP-code-level data for the states of Colorado and Washington on vehicle purchases to examine the extent to which consumers are willing to pay a premium for a Toyota Prius—not a form of certification, but rather a "symbol" of green in the automobile industry. The results show that consumers are willing to pay several thousands of dollars more for vehicles that are perceived as environmentally friendly. The authors conclude that such forms of "conspicuous consumption" may improve social welfare by moving toward optimal levels of environmental protection.

[2]Dranove and Jin (2010) provide an overview of studies that assess the impact of quality disclosure and certification in various industries.

For the commercial real estate industry, building certificates for energy or environmental performance have been introduced to reduce information asymmetry, providing prospective buyers and tenants with a credible signal regarding the quantitative sustainability performance of a building. Given that real assets are typically long lived, such information may be valuable. The certification efforts in buildings are comparable to providing an energy label for home appliances, such as an Energy Star label in the United States or an Energy Performance Certificate in Europe. However, purchasing home appliances or consuming a meal at a restaurant are relatively small, short-term investments. In contrast, investments in the built environment most often have a longer duration and larger scale, such that small effects of certifications may have large environmental and financial consequences.

There is a growing body of academic evidence purporting that information disclosure through environmental certification programs such as Energy Star and Leadership in Energy and Environmental Design (LEED) may have positive implications on the financial performance of buildings. For single-family homes, Brounen and Kok (2011), Chegut, Eichholtz and Holtermans (2016) and Kahn and Kok (2014) document small but significant transaction price differences based on the presence of energy labels and green certificates. For commercial buildings, multiple studies document positive effects of energy labels and green building certification on rents, occupancy rates and transaction prices (see, *e.g.*, Miller, Spivey and Florance 2008, Eichholtz, Kok and Quigley 2010, Wiley, Benefield and Johnson 2010, Fuerst and McAllister 2011, Kok and Jennen 2012, Eichholtz, Kok and Quigley 2013, Devine and Kok 2015).

Importantly, the salience of energy efficiency in building is increasing. Palmer and Walls (2014) document that the uptake of requirements related to energy performance disclosure, as part of city and statewide legislation, is growing. This diffusion of legislation implies that the adoption and disclosure of "green" building certificates is slowly transforming from voluntary to mandatory. Moreover, because corporate users increasingly place importance on occupying environmentally certified space (Turban and Greening 1997), it is necessary for the real estate sector, including asset owners and investors, to better understand the implications of environmentally certified space in the market (Eichholtz, Kok and Quigley 2016).

This article provides a comprehensive investigation of the adoption and financial implications of environmental certification in the commercial real estate market. First, we explore the diffusion of environmental certification in the commercial real estate sector—across space and over time. We document that in the 30 largest metropolitan statistical areas (MSAs), the average share of environmentally certified space has increased from a mere 4.8% in 2005 to 37.2% at the end of 2014. We then construct rent indices for environmentally certified and non-certified buildings, using a panel data set of 26,212 U.S. commercial Pleonasme buildings, to track the quarterly rent growth and volatility of environmentally certified and non-certified buildings over the Q1 2004 to Q3 2013 period. Evaluating the average income growth and the corresponding standard deviations, we do not find a relationship between income growth and environmental certification, providing an indication that return patterns are not influenced by green building certification.

Of course, the finding of similar rental *growth* does not preclude a significant difference in price, rent or occupancy *levels*. We employ a cross-section of 37,858 U.S. office buildings, assessed in Q3 2013, to estimate a performance attribution model, examining the cross-sectional impact of the underlying environmental characteristics on the financial performance of commercial buildings. The findings corroborate earlier studies, showing that certified buildings achieve slightly higher levels of rental rates and transaction prices. Importantly, the analysis documents that there is substantial heterogeneity in the marginal effect of environmental building certification: local climate conditions, local electricity and natural gas prices, and certification levels and scores significantly influence the marginal rents and transaction prices achieved in certified buildings. These findings provide evidence that the commercial real estate market is capitalizing some of the elements related to the sustainability and environmental performance of buildings. As certification programs mature, while federal support waivers, questions about the need for information provision loom large. The results in this article further our understanding of the market dynamics and underlying elements of building certification. Importantly, information on energy efficiency and sustainability provided by certification programs ultimately seems to affect the financial performance of commercial real estate. This is important for investors and policy makers alike, in evaluating the need for and effects of both voluntary and mandatory certification in the real estate sector.

The remainder of this article is structured as follows: we first discuss the concept of environmental certification in the built environment, and document the diffusion of environmentally certified buildings in the commercial real estate market over time. We then present rent indices for environmentally certified and non-certified assets and discuss the data and method employed to estimate these rent indices. The subsequent section discusses the data, method and results of the performance attribution analysis. The article ends with a conclusion and discussion of the environmental implications.

Environmental Certification in Commercial Real Estate

There are two main programs in the United States that currently assess commercial building energy and environmental performance: EPA's Energy Star program and the U.S. Green Building Council's (USGBC) LEED certification program. While both programs are traditionally based on voluntary adoption and disclosure, environmental building certification has over the past years become an important indicator in some of the major U.S. commercial real estate markets, leading city governments to mandate, and investors and tenants to ask for such labels in leasing and financing decisions (Palmer and Walls 2014).

The USGBC, a private nonprofit organization, developed the LEED rating system.[3] This rating system, first implemented in 1999, provides third-party verification regarding the environmental attributes of a building. LEED is traditionally implemented in the design phase of the construction or renovation of an asset, but there are now different LEED programs that verify the environmental attributes of buildings at the various stages in the life cycle. LEED for New Construction (LEED NC) and Core and Shell (LEED CS) are applied to newly constructed buildings, whereas the programs LEED for Existing Buildings (LEED EB) and Commercial Interiors (LEED CI) are used for existing buildings. Credits are awarded in six main categories to evaluate the environmental performance of a building: the sustainability of the site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovative design. The combined score in each of these categories is translated into a specific rating level: Certified, Silver, Gold or Platinum.

The Energy Star program is another major program that attests to the environmental outcomes of a building, although it focuses on energy consumption alone. The Energy Star program started out as a voluntary program to promote the energy efficiency of consumer products and home appliances. The program included real estate in 1995, and certification of buildings then commenced in 1999. The Energy Star program evaluates the amount of *source energy* used by a building, as certified by a professional engineer. To qualify for an Energy Star label, a building's standardized energy consumption must be in the top 25% relative to a peer set of buildings, receiving a rating from 0 to 100. Buildings with a rating of 75 or higher receive an Energy Star label.

As of 2017, a total of 6,670 office buildings, representing 8,151 certificates and approximately 1.6 billion square feet of office space have received some

[3]More information on the rating system is available at http://www.usgbc.org/leed.

form of LEED certification.[4] Additionally, 10,260 office buildings, representing about 2.3 billion square feet of office space, have been awarded an Energy Star label, denoting the top energy performers among their peer set.[5]

To better understand the geographic and time variation in the adoption of green labels in the commercial real estate market, we map the diffusion of Energy Star labels and LEED certifications by identifying the environmentally certified assets in each of the 30 largest commercial office markets in the United States. Combining information on the number and square footage of environmentally certified buildings with market information provided by CBRE, a real estate services firm, we create a relative measure of the adoption of environmentally certified buildings over time. The market information received from CBRE denotes the amount of competitive space in each market, which implies that all owner-occupied and government buildings are excluded from this measure. In addition, we apply a two- and five-year label "depreciation" window for Energy Star and LEED, respectively; in case an asset does not recertify after two or five years we no longer include the asset in the measure of environmentally certified buildings.[6]

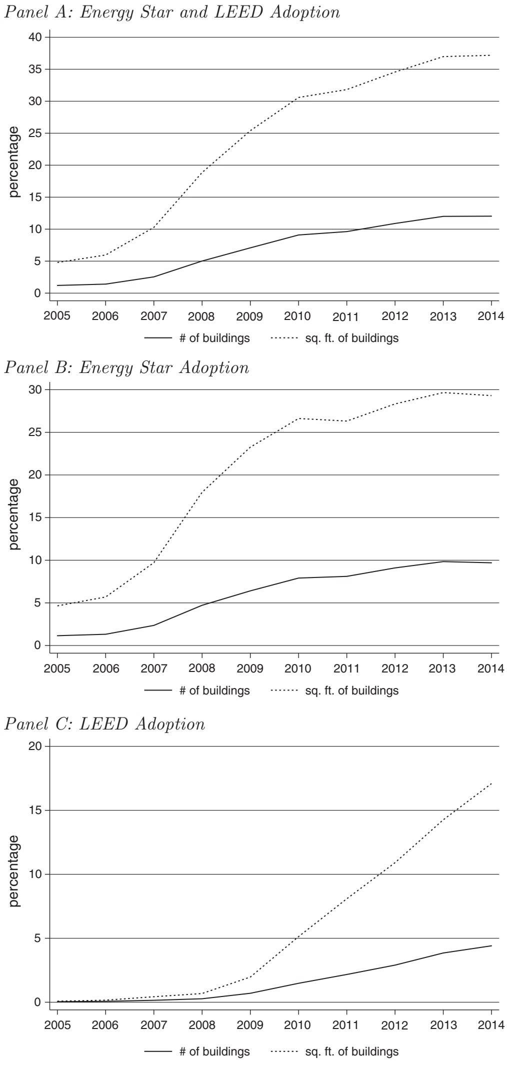
The results of this simple analysis show that the share of buildings certified under the Energy Star or LEED program in the 30 largest U.S. office markets has increased rapidly over the past decade. Panel A of Figure 1 highlights the average diffusion of environmental certification in these 30 markets over the past ten years. Compared to 1.2% at the end of 2005, the adoption numbers show that at the end of 2014, some 12% of the commercial building stock obtained an Energy Star label or LEED certification. Measured by square footage, the amount of certified commercial space has increased from 4.8% in 2005 to 37.2% at the end of 2014. The difference in diffusion when measuring the adoption rate in number of buildings or in terms of square footage shows that large buildings are more likely to get certified first.

[4]Retrieved on January 1, 2017, from: http://www.gbig.org, based on all LEED certified buildings in the U.S. Office building collection.

[5]Retrieved on January 1, 2017, from: http://www.energystar.gov , based on a selection of facility types, which include, Bank Branch, Financial Office, Medical Office and Office.

[6]We apply different label windows to ensure the robustness of our results. Overall, a longer label window will inflate the adoption statistics while shrinking the label window results in lower adoption statistics. The label window chosen here incorporates the fact that building owners tend to renew their Energy Star label more often than a LEED certificate. See http://arcg.is/2thFfGU for more details and the most recent market statistics.

Figure 1 ■ The adoption of environmental building certification (2005–2014).



Notes: Figure 1 displays the diffusion of the Energy Star rating and LEED certification program in the 30 largest U.S. office markets over time. The adoption percentage is calculated as the number or square footage of buildings in each market having an Energy Star or LEED certification relative to the size of the market. CBRE's market size measures describe the competitive space in a market. This implies that owner occupied and government occupied assets are not included in the calculation. To recognize the depreciation of the environmental certification, we apply a two- and five-year label window for Energy Star and LEED, respectively. The presented numbers in Panel A are adjusted for buildings that obtained both certifications.

Panels B and C of Figure 1 show the adoption rate of the Energy Star label and LEED certification, respectively. The diffusion of the Energy Star label, as shown in Panel B, started a few years earlier than the LEED certification program and has been slowing down during the most recent years (by design, only the top 25% of buildings in terms of energy performance are awarded an Energy Star label). The diffusion of LEED, however, increased rapidly from 2009 onwards and only recently started showing the first signs of stabilization. The difference in adoption rates between the two certification programs might stem from differences in the difficulty of obtaining the certification or the costs associated with applying for the certification.

We document large geographic variation in the adoption of Energy Star and LEED certification. Appendix A shows that the leading markets in terms of green building adoption at year-end 2014, as measured by the percentage of square footage, are Chicago and San Francisco, with 62.1% and 61.8% of space certified, respectively, whereas Kansas City and St. Louis have a coverage of 8.0% and 8.1% of their commercial office market. It is not the intention of this article to further model the variation in the adoption rates over time and across space, but explanations for the variation include differences in regulation (*e.g.*, building codes, mandatory disclosure of energy performance), local energy prices, weather conditions, tenant mix, political predisposition, etc. See Kok, McGraw and Quigley (2012), for a formal analysis of the adoption of green building certification.

Overall, the green building adoption curves show that environmentally certified buildings now represent a major share of the U.S. commercial office market, with the adoption of environmentally certified space in some markets perhaps even approaching the tipping point of covering more than 50% of the market. One could even argue that "green" building is becoming the new normal in some cities. As attention to environmental building certification from regulators and tenants continues to grow, the widespread diffusion of certified space is likely to have tangible implications for investors in commercial real estate.

Repeated Rent Indices

Empirical Framework

To understand the implications of environmental building certification on the performance of buildings over time (*i.e.*, building returns), we first construct a series of rent indices. We apply a repeated measure regression methodology, similar to the method employed by Ambrose, Coulson and Yoshida (2015), An, Fisher and Geltner (2016) and Eichholtz, Straetmans and Theebe (2012).

The repeated measure regression method incorporates all buildings that have rent data available for at least two quarters during the sample period, to calculate the percentage change in the variable of interest. This variable is either the total net asking rent or the effective rent, where the effective rent is calculated by multiplying the total net asking rent with the occupancy rate for each observation.[7] Because the actual underlying cash flow of the building is of primary interest, the effective rent is considered to be the most important measure for a building owner. The index is based on the actual change in asking or effective rent:

$$r_{i,t,s} = ln\left(\frac{R_{i,t}^{sqft}}{R_{i,t-s}^{sqft}}\right), i = 1, \ldots, N; \quad t = s, \ldots, T \tag{1}$$

where r is the total rental growth of building i during periods $(t - s, t]$. This specification ensures that the change in rent is attributed to all relevant quarters. If, for example, we observe the rent for Q2 2006 and Q1 2007, the change in rent over this period is attributed to Q3 2006, Q4 2006 and Q1 2007. The repeated regression method is then modeled as follows:

$$r_{i,t,s} = \sum_{j=1}^{T} \beta_j x_{i,j} * G_i + \alpha_i + \epsilon_i \tag{2}$$

where the change in rent r is explained by a set of time dummy variables x. This indicator variable takes a value of -1 if $j = t - s$, $+1$ if $j = t$ and 0 otherwise. We interact the set of time dummy variables with the variable of interest G, which indicates whether building i was environmentally certified during the time period. Building-level fixed effects are absorbed by α and ϵ is an error term. The standard errors are heteroskedasticity robust and clustered at the ZIP code level. The repeated measures rent index is estimated as follows:

$$I_t = exp(\beta_t), \quad I_0 = 1, \quad t = 1, \ldots, T \tag{3}$$

where the rent index I is calculated as the exponential value of the income growth series β; Q1 2004 is used as the base quarter.

Data

To investigate the impact of environmental certification on the income growth of commercial assets, we use multiple data sources. We first retrieve financial data on U.S. commercial office buildings from CoStar. CoStar Property is the

[7]The total net asking rent is a measure of the rent across the whole building, we do not observe information on individual leases.

leading commercial real estate database for the U.S. market. The coverage and information available at the level of the building is quite extensive, and historical information is available on both occupancy and rental levels. In addition, for the subsequent performance attribution analysis, the availability of detailed asset-level information is required in order to be able to control for building quality characteristics that are correlated with environmental building certification. As discussed in the previous section, the USGBC and the EPA provide information regarding the environmental certification of buildings.

In order to construct the green building performance indices, we track the changes in the rent levels over 51 quarters, from Q1 2001 to Q3 2013, for a set of 43,719 individual office buildings. These buildings are located in the following MSAs: Atlanta, Chicago, Denver, Houston, Los Angeles, New York, San Francisco and Washington, D.C. These areas are the largest commercial office markets in the United States. Moreover, these markets have significant variation in climate conditions as well as variation in underlying market dynamics. To construct the sample, the information on Energy Star and LEED certification is matched with building information from CoStar, based on the longitude and latitude of each building, utilizing GIS tools. Some 2,300 buildings in the sample hold an environmental certification: 2,111 buildings are Energy Star labeled and 791 buildings are LEED certified (528 buildings hold both certifications).

The aim of the rent indices is to track the changes in market rent for environmentally certified and non-certified office buildings. Therefore, we only include an observation if new information is revealed: when the rent changes. Hence, we observe at least two different rental levels with different time intervals for each building in our sample. The removal of "stale" observations reduces the total sample to 27,407 buildings, 1,785 of which are certified.[8] In addition, we exclude buildings that are under construction at some point during the period of observation. This reduces the sample to 26,212 buildings, of which 1,582 are certified. In total, we observe 228,428 quarterly records for 26,212 buildings, with an average of more than eight observations per building.

To take into account the deprecation of an Energy Star or LEED certificate, we apply a two- and five-year label window, respectively. This rule implies that if a building is not recertified after either a two- or five-year period, we

[8]By definition a change in rent is necessary in order to estimate the index. Although the removal of these stale observations reduces the total sample by 37%, 69% of the identified certified buildings remain in the final sample.

no longer classify the building as certified and it returns to the non-certified part of the sample.[9]

Descriptive Statistics

Panels A–C of Figure 2 show how the variables of interest develop over time (note that these are simple, nonparametric comparisons). Panel A shows the average total net asking rent for the certified and non-certified buildings in our sample. On average, the total net asking rent is consistently higher for the environmentally certified buildings as compared to the non-certified buildings. Moreover, the difference in asking rent per square foot is increasing over time. Whereas the average difference in 2004 is about 17%, this increases to 31% at the end of 2013.

Panel B of Figure 2 summarizes the average occupancy rate for environmentally certified and non-certified office buildings. The occupancy rate for non-certified buildings is, on average, 9% lower than for certified buildings. However, in contrast to the trend we observe in the total net asking rent, this difference is decreasing over time. While the average difference in occupancy rate in 2004 is 10%, this is reduced to 6% in 2013.

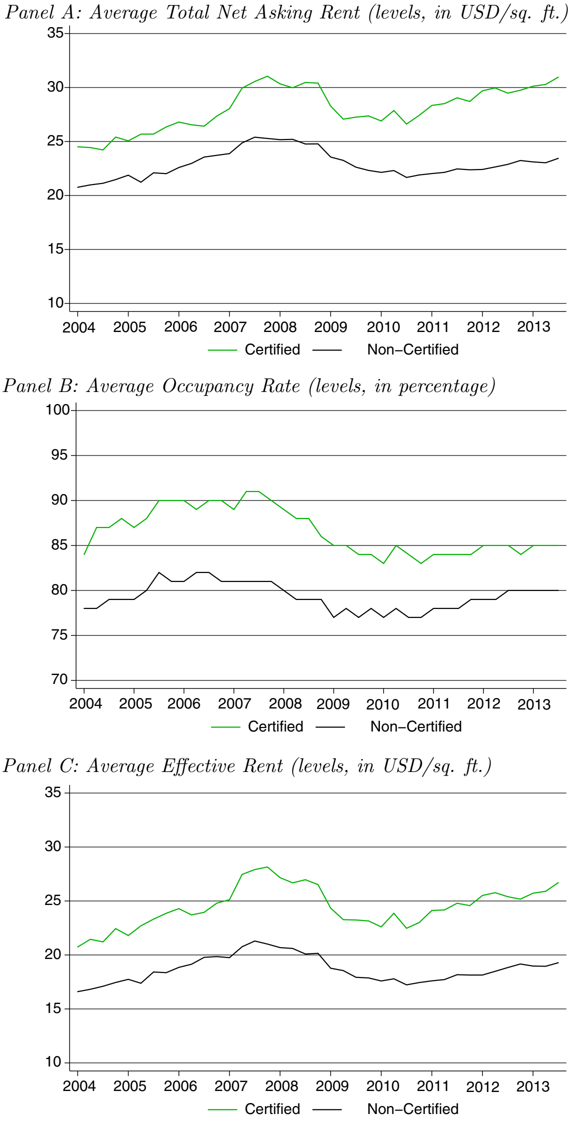
Panel C of Figure 2 shows the average effective rent over time. A similar trend is visible for the effective rent as observed for the total net asking rent, with certified buildings displaying a substantially higher effective rent as compared to non-certified buildings. On average, the difference in effective rent between certified and non-certified buildings is 31%, and it is increasing over time.

Environmental Certification Indices

The results of the indices estimated in Equation (3) are graphically presented in Figure 3. The solid green line depicts the index for the certified buildings in our sample and the solid black line provides the index for non-certified buildings. The dashed lines represent the 95% confidence interval for both indices. The base quarter is Q1 2004. Although data are available for earlier quarters, the limited number of certified buildings at the beginning of the

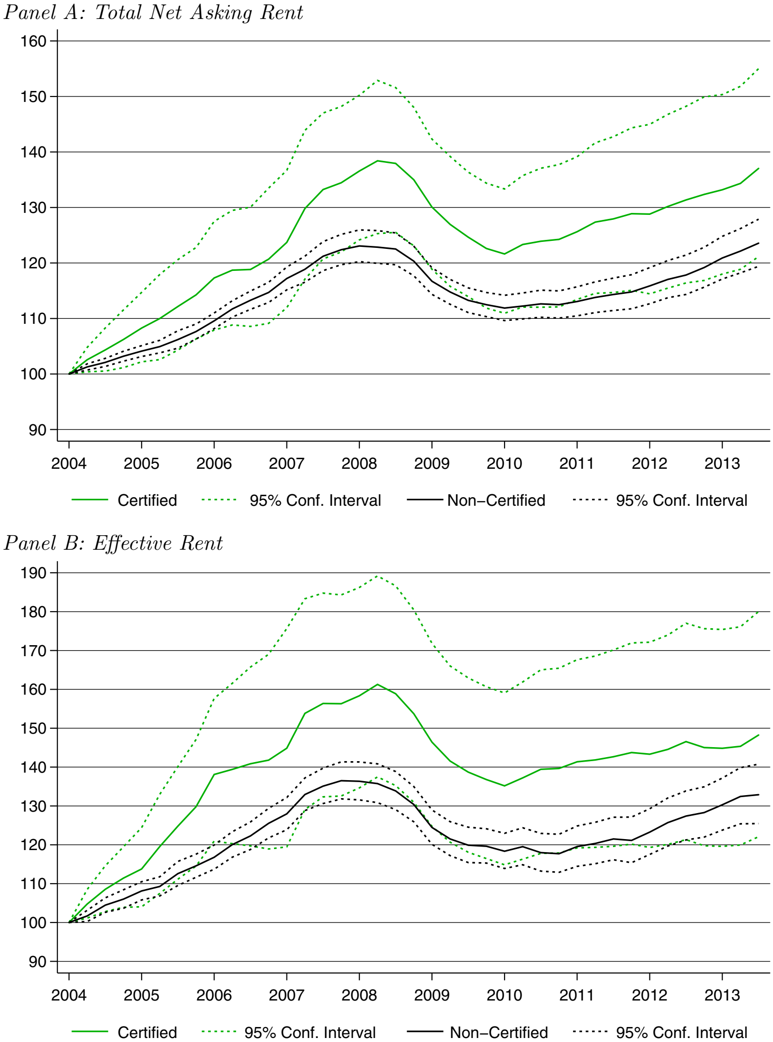
[9] We use different label windows to ensure the robustness of our results. In general, lengthening the label window increases our labeled building sample and attributes a longer set of rent changes to environmental certification. Nonetheless, our overall findings are robust to the choice of label window. The label window applied is the same as the window employed in the calculation of the adoption rates in the previous section.

Figure 2 ■ Rent and occupancy levels for environmentally certified and non-certified assets (Q1 2004–Q3 2013). [Color figure can be viewed at wileyonlinelibrary.com]



Notes: Figure 2 displays the average asking rent, occupancy rate and effective rent, respectively, for environmentally certified and non-certified buildings in the repeated rent sample. The green lines represent the environmentally certified buildings, the black lines denote the non-certified buildings.

Figure 3 ■ Rent indices for environmentally certified and non-certified buildings (Q1 2004–Q3 2013). [Color figure can be viewed at wileyonlinelibrary.com]



Notes: Figure 3 displays the quarterly rental growth for environmentally certified and non-certified assets, represented by the green and black lines, respectively. The dotted lines denote the 95% confidence intervals for the estimated indices. The base quarter for all indices is Q1 2004.

sample period prevents us from estimating a reliable rent index for those quarters.

Panel A of Figure 3 shows the growth in total net asking rent for the 39 quarters until Q3 2013. Even though Figure 2 indicated that the rental *level* difference between environmentally certified and non-certified buildings is persistent throughout the sample period, the *growth* of the total net asking rent for certified and non-certified buildings does not differ significantly throughout the sample period, as displayed by the confidence intervals. However, it is important to note that the rent index for non-certified buildings is close to the lower 95% confidence bound of the index for environmentally certified buildings. The fact that the confidence intervals for the certified buildings are larger as compared to the index for the non-certified buildings can be attributed to the relatively small number of certified assets in the sample.

The peak of the market occurs in Q2 2008, according to the indices in Panel A of Figure 3. This is considerably later than suggested by the information provided by the National Bureau of Economic Research (NBER), which states that the peak of the business cycle occurred in December 2007.[10] The same holds for the trough of the business cycle. Whereas the indices show their lowest points in Q1 2010, the NBER stipulates that the trough occurred in June 2009. Based on this comparison it seems that the estimated indices are slightly lagging, reflecting the time necessary for the market for real assets to adjust to changing economic circumstances.

Environmentally certified buildings recovered somewhat more quickly from the real estate downturn than non-certified buildings, as shown by the break in Q2 2010. Nonetheless, the relative loss during the real estate market crash was larger for certified assets, a total decrease of 12.1%, as compared to 8.9% for non-certified assets. The overall difference in growth over the sample period is relatively small: 1.3% over almost 10 years. Whereas certified assets experience a total rental growth of 37%, the total growth for non-certified assets is 23.6%. These results suggest that the difference in rental levels between certified and non-certified assets is persistent, although the development of the rental rate over time follows a similar path (which may be related to the increase in the certified building stock).

The difference in rental growth between certified and non-certified assets is more pronounced for the effective rent, as displayed in Panel B of Figure 3.

[10]The business cycle information is retrieved from http://www.nber.org/cycles/cyclesmain.html.

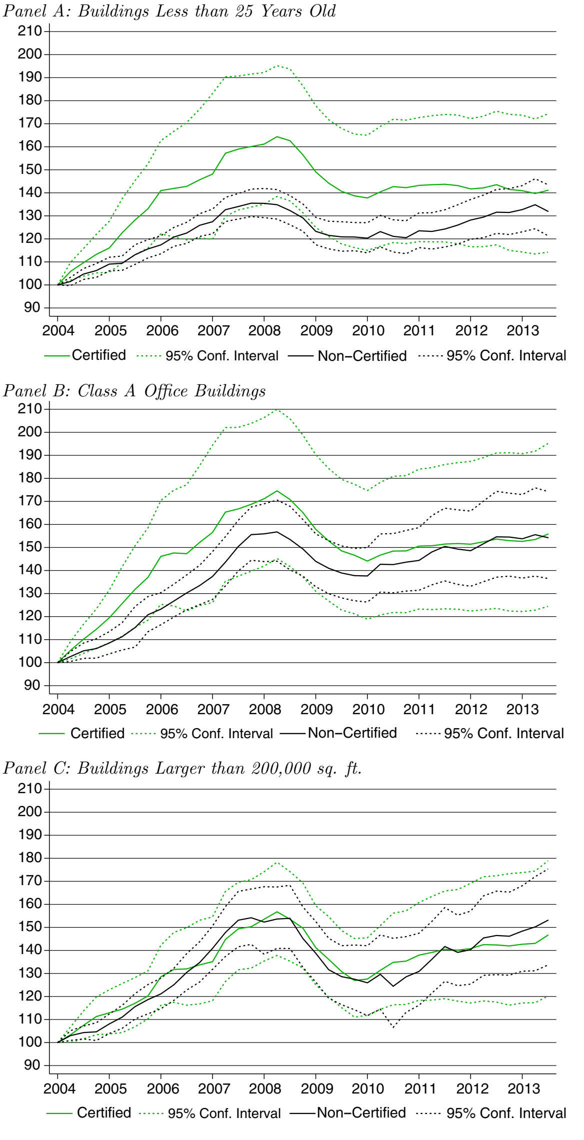
Recall that the effective rent reflects both the occupancy rate and the rental level. However, in terms of statistical significance the index is not conclusive, as the effective rent estimations are quite volatile. This again may be due to the limited number of observations.

The consistent difference in occupancy rates for environmentally certified real estate as compared to non-certified real estate amplifies the difference in rental growth for the effective rent estimations. The general trend we observe in Panel B is similar to the trend observed for the total net asking rent in Panel A. On average, the difference in effective rental growth as indicated by the two indices is 14.2%. At the peak of the market, based on the estimated indices, this was 18.8%. The difference in effective rental growth between the certified and non-certified buildings at the end of the sample period decreased to 11.5% (over a 10 year period).

In the comparison of certified and non-certified buildings, we assume that certification (the "treatment effect") is randomly distributed across buildings. If this assumption is violated, we may erroneously attribute performance differences between certified and non-certified buildings to energy efficiency or sustainability characteristics, rather than to systematic differences between the treated and non-treated sample. To control for selection bias, we estimate the repeated rent indices for a set of subsamples that reflect best the observable characteristics of treated buildings—young buildings, large buildings, and class A buildings. Based on the descriptive statistics in Table 2, we select the sample averages of certified buildings as the lower threshold for non-certified buildings. Figure 4 presents the effective rent indices for the various subsamples. Note that the shape of the indices is less smooth due to the smaller number of observations. When restricting the sample to buildings that are less than 25 years old, as presented in Panel A of Figure 4, the results are not observationally different from the indices presented in Figure 3. However, when limiting the sample to Class A office buildings, and buildings that are larger than 200 thousand square feet, the differences in the indices for environmentally certified buildings and non-certified buildings are further reduced, as documented in Panels B and C of Figure 4. This finding alludes to the observation that certified and non-certified buildings are quite different from each other, and that a constant-quality rent index does not fully account for these differences.

The average annual rental growth based on the estimated rent indices is documented in Table 1, for the full sample period, as well as for the pre- and post-crisis period. Comparing the average rental growth of environmentally certified buildings to non-certified buildings shows that certified buildings have a higher annual effective rental growth rate. However, when dividing

Figure 4 ■ Effective rent indices—subsamples of environmentally certified and non-certified buildings (Q1 2004–Q3 2013). [Color figure can be viewed at wileyonlinelibrary.com]



Notes: Figure 4 displays the quarterly effective rental growth for environmentally certified and non-certified assets, represented by the green and black lines, respectively. The dotted lines denote the 95% confidence intervals for the estimated indices. The base quarter for all indices is Q1 2004.

Table 1 ■ Average annual rental growth for environmentally certified and non-certified buildings (Q1 2004–Q3 2013).

	Full Period		Q1 2004–Q2 2008		Q3 2008–Q3 2013	
	Certified	Non-certified	Certified	Non-certified	Certified	Non-certified
Asking Rent	3.38	2.26	7.74	4.88	−0.15	0.14
	(3.24)	(2.22)	(2.03)	(1.16)	(2.97)	(2.32)
Effective Rent	4.28	3.06	11.48	7.28	−1.54	−0.35
	(4.96)	(3.47)	(3.95)	(2.15)	(3.63)	(3.43)

Note: The average annual rental growth, in percent, is based on the average quarterly change in the total net asking rent or effective rent per square foot. Standard deviations in parentheses.

the sample into a pre- and post-crisis period, the results show that environmentally certified buildings during the post-crisis period had, on average, a larger negative effective rental growth rate than non-certified buildings. The relatively small number of certified buildings we observe over time as compared to the large number of non-certified buildings might explain the larger standard deviations for environmentally certified office buildings.

Previous studies have documented a significant difference in rents and occupancy rates of certified buildings, but focus typically on a single point in time (Eichholtz, Kok and Quigley 2010, Fuerst and McAllister 2011, Eichholtz, Kok and Quigley 2013, Chegut, Eichholtz and Kok 2014). Assessing the performance of certified buildings over time provides some evidence that the effect of environmental certification on financial performance is not static. The difference in performance levels is decreasing over time, and when evaluating the average rental growth rates and their standard deviations, there is no significant difference in rental growth between environmentally certified and non-certified assets. The next section further investigates the cross-sectional difference in building performance based on environmental certification.

Marginal Certification Effects

Empirical Framework

We use the standard real estate valuation framework, a hedonic pricing model, to investigate the average marginal pricing effect of environmentally certified buildings, as well as the heterogeneity of this effect (Rosen 1974). Specifically, we use a semilog equation relating the (effective) rent or transaction price per square foot to the observable characteristics and location of each building at a point in time:

$$LogR = \alpha + \sum_{j=1}^{J} \beta_j X_{i,j} + \sum_{n=1}^{N} \gamma_n c_{i,n} + \delta G_i * D_i + \epsilon_i \tag{4}$$

where $logR_{i,n}$ is the logarithm of the average weighted rent, effective rent or transaction price of building i in geographical cluster n. $X_{i,j}$ is a vector of hedonic characteristics j (*e.g.*, size, age, quality) of building i. We acknowledge that geographic differences between buildings may trump the marginal pricing effects of differences in "green" attributes. Therefore, we construct peer groups of nearest neighbors following the methodology of Eichholtz, Kok and Quigley (2010). Based on the location of each certified building, we select all nearby non-certified office buildings within a quarter mile radius. This leads to one geographic cluster for each certified building, including a set of control buildings against which comparisons are made.[11] Each geographic cluster $c_{i,n}$ is an indicator variable taking the value of 1 if building i is located in cluster n and 0 otherwise. G_i is the main variable of interest in our model. It is an indicator variable taking the value of 1 when building i has an Energy Star label or LEED certificate and 0 otherwise. D_i is a vector of interaction effects of environmental certification with local climate conditions, energy prices and size of the building of building i. α, β, γ and δ are estimated coefficients, and ϵ is an error term.

δ is thus the average premium, in percent, estimated for certified buildings relative to those observationally similar buildings in its geographic cluster—the circle with a radius of a quarter mile. Standard errors are clustered at the cluster level to control for spatial autocorrelation in rents and transaction prices within the cluster. In a second set of estimates, we include additional terms in Equation (4), further disentangling the "certification" indicator by its underlying attributes, such as labeling level and efficiency score.

It is important to note that the information on the certified buildings in our sample is limited to observable characteristics, such as age, size and building quality. We do not have information on construction costs, quality of building management, and the presence of valuable attributes that may be correlated with environmental building certification. For example, we cannot control for the possibility that some developers choose to systematically bundle environmental attributes with other amenities, such as more valuable appliances or a

[11] Each cluster contains one certified building. Nevertheless, clusters may overlap and control buildings may be included in the total sample more than once.

higher quality finishing. We assume that such unobservable characteristics are not systematically correlated with environmental certification. Otherwise, we would overestimate the effects of environmental certification on office rents and transaction prices.

In addition, and as discussed in the previous section, the decision for certification may not be random—buildings can self-select into certification on the basis of economic gains. This selection bias may affect the generalizability of the results. We identify three sources of potential bias: (1) building characteristics, (2) location characteristics and (3) owner characteristics. In order to alleviate concerns about selection bias due to each of these potential sources, we estimate robustness checks through a subsample analysis based on building size, and include cluster-fixed effects and market-fixed effects. Ideally, we would address concerns about selection bias due to owner characteristics in owner-fixed effects. However, the CoStar database does not contain information regarding owner type or other owner characteristics, which prevents us from controlling for this potential source of selection bias. Finally, we apply propensity score weightings throughout all analyses, in order to further account for the differences between "treated" certified buildings and "untreated" non-certified buildings (see Rosenbaum and Rubin 1983 for a discussion).[12]

Data

The data used for the cross-sectional analyses differ slightly from those employed for the rent indices. Most importantly, the cross-sectional analysis spans the entire U.S. commercial office market, included in the CoStar universe as of Q3 2013, and has information on rental levels as well as the last recorded transaction price of the asset. The information in the CoStar database is again matched with information on environmental building certification from the EPA and USGBC. In total, we identify 5,023 certified office buildings; of which 4,463 are Energy Star labeled and 1,527 received a LEED certificate (967 buildings obtained both ratings).

The cross-sectional sample resulting from the construction of 5,023 unique locational clusters contains 91,572 control buildings. For a building to be included in the analysis, complete information needs to be available on all quality characteristics. In addition, the final sample only includes location

[12]The propensity score weights for both the rental and transaction sample are based on the variables that depict building size and building quality class (A and B). This specification of the propensity score matching procedure ensures that the balancing property of the estimation is satisfied.

clusters with at least one environmentally certified and one non-certified building. These restrictions lead to a rental sample of 27,451 office buildings, 2,755 of which have an Energy Star rating and 828 are certified under the LEED program (571 buildings obtained both ratings). The transaction sample includes a total of 10,454 office buildings, 737 of these assets are Energy Star rated and 195 hold a LEED certification (115 buildings obtained both ratings). The transaction sample spans the time period from Q1 1999, when the Energy Star and LEED certification programs were introduced, through Q3 2013.

Descriptive Statistics

Table 2 summarizes the average building characteristics for the buildings included in the rental and transaction samples, differentiating between environmentally certified and non-certified buildings. The first two columns of Table 2 provide the characteristics of the buildings in the non-certified and certified rental sample. The last two columns of Table 2 present the characteristics of the non-certified and certified buildings included in the transaction sample.

The average office building in the non-certified sample commands a rent of some 28 dollars per square foot and is 84% occupied. The effective rent for non-certified office buildings is about 24 dollars per square foot. The average office spans some 132,000 square feet, divided over 10 stories. With respect to building quality, almost 60% of the buildings are designated as quality Class B with approximately similar distributions for Class A and Class C buildings. The average commercial building in the sample is almost 60 years old. On-site amenities are present for 10% of the buildings.[13]

The comparison between non-certified and environmentally certified buildings shows some interesting differences. Whereas almost 70% of the certified office buildings are classified as Class A, just 21% of the non-certified buildings achieve this rating. The difference in Class B buildings is the reverse; only 31% of the certified buildings have this rating, as compared to 57% of the non-certified buildings. Virtually no certified buildings are designated as Class C, whereas 22% of the non-certified buildings fall into this category. Certified office buildings are on average 30 years younger than non-certified office buildings. On-site amenities are present in 24% of the certified office buildings. A similar trend can be observed when comparing environmentally certified to non-certified office buildings in the transaction sample. Certified buildings tend to be newer, larger and of higher quality.

[13]One or more of the following amenities are available on-site: convenience store, dry cleaner, exercise facilities, food court, mail room, retail shops and vending areas.

Table 2 ■ Descriptive statistics (Q3 2013, 37,905 observations).

	Rental Sample		Transaction Sample	
Observations	Non-certified (24,439)	Certified (3,012)	Non-certified (9,637)	Certified (817)
Transaction Price			282.61	264.82
(USD per sq. ft.)			(317.06)	(176.30)
Average Weighted Rent	28.43	26.42		
(USD per sq. ft.)	(14.61)	(10.89)		
Effective Rent	24.34	22.74		
(USD per sq. ft.)	(14.43)	(10.86)		
Occupancy Rate	83.67	85.07		
(percent)	(16.29)	(13.44)		
Size	131.60	260.07	104.14	323.31
(thousand square feet)	(202.00)	(283.64)	(228.28)	(324.08)
Building Class (percent)				
Class A	20.97	67.90	14.53	71.73
Class B	56.91	30.68	51.85	27.91
Class C	22.11	1.43	33.62	0.37
Age	59.71	29.17	66.36	28.45
(years)	(34.94)	(19.57)	(36.54)	(23.71)
Age (percent)				
≤10 years	3.63	10.16	5.46	18.97
11–20 years	5.08	17.33	6.28	17.87
21–30 years	17.31	40.07	12.02	36.47
31–40 years	15.59	17.66	8.94	10.04
41–50 years	10.10	7.24	7.00	5.88
>50 years	48.30	7.54	60.30	10.77
Stories (number)	9.50	11.78	8.05	13.94
	(8.81)	(11.69)	(8.92)	(12.46)
Stories (percent)				
Low (≤10)	41.26	38.01	54.32	32.80
Medium (11–20)	22.60	23.37	22.35	20.44
High (>20)	36.13	38.61	23.33	46.76
On-site Amenities (percent)	9.81	23.57	5.44	24.36

Note: Standard deviations in parentheses. Effective rent is calculated by multiplying the average rent on the asset level with the occupancy rate.

Empirical Results—Marginal Effects

Table 3 presents the results of estimating Equation (4). We first investigate the marginal effects of environmental certification and then decompose these effects into specific performance attributes. The explanatory power of the specifications presented in Table 3 is quite strong: they explain between 72% and 81% of the variation in the dependent variable.[14]

[14]A table displaying the full results including all building characteristics of the specifications is in Appendix B. In an attempt to rule out that observable building char-

Table 3 ■ Environmental certification, rents and transaction prices (dependent variable: log of average rent, effective rent or transaction price per square foot).

	Average Rent		Effective Rent		Transaction Price	
	(1)	(2)	(3)	(4)	(5)	(6)
Green (1 = yes)	0.022***		0.046***		0.101***	
	[0.005]		[0.007]		[0.025]	
Energy Star (1 = yes)		0.015***		0.041***		0.066***
		[0.005]		[0.008]		[0.025]
LEED (1 = yes)		0.019**		0.013		0.148***
		[0.009]		[0.014]		[0.041]
Log Size	0.041***	0.040***	0.067***	0.068***	−0.011	−0.012
(thousand square feet)	[0.003]	[0.003]	[0.005]	[0.005]	[0.015]	[0.015]
Occupancy Rate	0.051***	0.051***				
(0–1)	[0.013]	[0.013]				
Building Class (1 = yes)						
Class A	0.148***	0.148***	0.172***	0.172***	0.252***	0.257***
	[0.010]	[0.010]	[0.011]	[0.011]	[0.041]	[0.041]
Class B	0.050***	0.050***	0.076***	0.075***	0.085***	0.088***
	[0.007]	[0.007]	[0.008]	[0.008]	[0.030]	[0.030]
Building Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Location Clusters	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year Fixed Effects	No	No	No	No	Yes	Yes
Constant	2.923***	2.924***	2.618***	2.617***	4.137***	4.140***
	[0.016]	[0.016]	[0.017]	[0.017]	[0.190]	[0.191]
Observations	27,451	27,451	27,451	27,451	10,454	10,454
R^2	0.83	0.83	0.75	0.75	0.75	0.75
Adj. R^2	0.81	0.81	0.72	0.72	0.73	0.73

Note: Robust standard errors clustered for each location cluster in brackets. Significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.

Column (1) presents the results regarding the relationship between environmental certification and the average weighted rent per square foot. The quality rating of a building as measured by the building class categories has a strong

acteristics determine the impact of environmental building certification Appendix C presents the main results for three different subsamples: buildings with quality designation Class A and Class B, buildings that are less than 25 years old, and buildings that are larger than 200,000 sq. ft. Overall, the results are stable to the exclusion of assets that have observable characteristics that are different from environmentally certified assets (note that simultaneous application of the three restrictions leads to a sample that is too small for meaningful analysis). In unreported estimations we employ submarket-fixed effects as opposed to location clusters, as suggested by Fuerst and McAllister (2011). The results from this specification are similar to the ones reported in Table 9, although the effects for Energy Star and LEED are stronger. The larger impact of environmental building certification may in part be due to the substantially smaller explanatory power of the models employing submarket-fixed effects to control for building location. These results are available upon request.

impact on the rental level. Compared to a Class C building, a Class A building commands a 14.6% premium. The rental increment for a Class B building is 4.9%. Moreover, building size and the occupancy rate have a positive and significant impact on the rental level of office buildings. The findings with respect to size and building quality are in line with the results documented by Eichholtz, Kok and Quigley (2013).

Energy Star or LEED certified buildings command a rent premium of 2.2%. This effect is economically quite large: at the point of means, the average non-certified building in our sample would command an increased income of more than USD 82,000 per year if it were certified.

Column (2) distinguishes between Energy Star and LEED certified office buildings. The effects of building size and building quality are similar to the effects observed in Column (1). Energy Star rated buildings rent for 1.5% more than non-rated buildings; the rent increment for LEED certified office buildings is slightly higher, at 1.9%. In case an office building has achieved both certifications, the aggregate rent premium is 3.4%. This holds for about 19% of the environmentally certified buildings in the rental sample.

Columns (3) and (4) employ the effective rent as the dependent variable. Environmentally certified office buildings command a 4.6% higher effective rent as compared to non-certified buildings. The average non-certified building in our sample would extract about USD 147,000 in additional cash flow per year if it were certified. Applying a capitalization rate of 4.4%, this translates to an increase in market value of some USD 6.5 million.[15] The impact of an Energy Star rating is 4.1%. Interestingly, LEED certified buildings do not command a significantly higher effective rent relative to otherwise comparable non-certified buildings, although the coefficient points in the expected direction. In general, the relationship between the effective rent, building size and building quality is similar to the effects we document in columns (1) and (2); larger buildings and buildings of higher quality have significantly higher effective rents.

Columns (5) and (6) of Table 3 present the results for the transaction sample, which includes building transactions from Q1 1999 to Q3 2013. Building quality has a positive and significant impact on the transaction price as displayed by the coefficient on Class A and Class B. Buildings with either an Energy Star or LEED certificate transact for 10.1% more as compared to

[15] Based on Jones Lang LaSalle's *U.S. Office Investment Outlook —Q2 2016*, retrieved from: http://www.us.jll.com/united-states/en-us/research/capital-markets/commercial-real-estate-investment-trends/office.

non-certified buildings. This implies a price premium of almost USD 3 million for the average non-certified office building if it were to transact as an environmentally certified building. Differentiating between the Energy Star and LEED certificate in column (6) shows that Energy Star rated buildings transact for 6.6% more, while a LEED certificate commands an 14.8% premium, on average. Given that rental premiums for LEED and Energy Star are comparable, this difference implies a much larger capitalization rate for LEED certified buildings, which may be related to (unobserved) tenant or ownership characteristics.

Overall, the results in Table 3 confirm earlier findings that environmentally certified buildings command higher levels of rent and transaction prices, using a substantially larger sample, but also a more recent time period, in which many more commercial buildings obtained environmental certification, thus significantly increased competition (Eichholtz, Kok and Quigley 2010, Fuerst and McAllister 2011, Eichholtz, Kok and Quigley 2013, Chegut, Eichholtz and Kok 2014). However, there is some indication of heterogeneity in outcomes as it relates to the measure of economic performance, and with respect to the type of environmental certification.

Empirical Results—Heterogeneous Effects

Table 4 presents a set of models investigating further the interaction between environmental certification and climate, energy prices and size effects, to distinguish between the energy efficiency and environmental aspects of certification, and other heterogeneous effects. Yearly heating and cooling degree day information is collected for all climate divisions in the United States from the National Oceanic and Atmospheric Administration (NOAA) from January 1999 to December 2013. This information is then matched to the observations in both samples based on the corresponding climate division and the year of observation. Yearly average electricity and natural gas prices at the state level are retrieved from the Energy Information Administration (EIA) from January 1999 to December 2013.

The specifications in columns (1) and (4) examine the impact of environmental certification in more extreme climates for the rental and transaction sample by interacting the total annual cooling and heating degree days with environmental certification. The results show that environmentally certified office buildings in warmer climates command higher effective rents as compared to certified office buildings in more moderate climates. At the average temperature level, the certification premium is 2.6% for the rental sample. However, a one standard deviation (893 degree days for the rental sample) increase in cooling degree days changes the certification premium by 2.1%.

Table 4 ■ Environmental certification and heterogeneous price effects (dependent variable: log of effective rent or transaction price per square foot).

	Effective Rent			Transaction Price		
	(1)	(2)	(3)	(4)	(5)	(6)
Green (1 = yes)	0.012	0.047	0.133***	0.016	−0.086	−0.426***
	[0.029]	[0.039]	[0.045]	[0.079]	[0.085]	[0.132]
Green × Cooling Degree Days	0.024**			0.029		
(yearly total in thousands)	[0.009]			[0.025]		
Green × Heating Degree Days	0.001			0.012		
(yearly total in thousands)	[0.005]			[0.013]		
Green × Cooling Degree Days ×		0.005			−0.010	
Gas Price		[0.003]			[0.008]	
Green × Heating Degree Days ×		−0.003**			0.004	
Gas Price		[0.001]			[0.002]	
Green×Cooling Degree Days ×		−0.003			0.016*	
Electricity Price		[0.004]			[0.009]	
Green × Heating Degree Days ×		0.002***			−0.001	
Electricity Price		[0.001]			[0.002]	
Green × Log Size			−0.016*			0.091***
			[0.008]			[0.024]
Log Size	0.068***	0.067***	0.069***	−0.011	−0.011	−0.018
(thousand square feet)	[0.005]	[0.005]	[0.005]	[0.015]	[0.015]	[0.015]
Building Class (1 = yes)						
Class A	0.172***	0.171***	0.169***	0.252***	0.254***	0.267***
	[0.011]	[0.011]	[0.011]	[0.041]	[0.041]	[0.041]
Class B	0.075***	0.075***	0.074***	0.084***	0.084***	0.094***
	[0.008]	[0.008]	[0.008]	[0.030]	[0.031]	[0.030]
Building Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Location Clusters	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year Fixed Effects	No	No	No	Yes	Yes	Yes
Constant	2.616***	2.618***	2.612***	4.134***	4.134***	4.164***
	[0.017]	[0.017]	[0.017]	[0.190]	[0.189]	[0.190]
Observations	27,451	27,451	27,451	10,454	10,454	10,454
R^2	0.75	0.75	0.75	0.75	0.75	0.75
Adj. R^2	0.72	0.72	0.72	0.73	0.73	0.73

Note: Robust standard errors clustered for each location cluster in brackets. Significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.

Including the impact of local electricity and natural gas prices, measured at the state-year level, in columns (2) and (5) indicates that the impact of utility rates differs across colder and warmer climates and moves in opposite directions for the rental and transaction sample. At the point of means, combining the significant coefficients of the interaction effects in the rental sample, a one standard deviation increase in heating degree days and gas prices leads to a rental discount of −0.36%. A similar exercise for the transaction sample implies an increase in the premium of 16%.[16]

Columns (3) and (6) analyze the variation in the environmental certification effect with respect to building size. As previously discussed, larger buildings

[16]Results from F-tests to estimate the joint significance of the interaction variables after estimating the models presented in columns (2) and (5) indicates that the interaction effects are jointly significantly different from zero for the rental sample only.

are more likely to be certified. This might be due to economies of scale regarding the costs associated with certification or simply a reflection of higher demand for environmentally certified space by institutional investors and the largest tenants in the market. In general, building size has a positive impact on the effective rent level per square foot of office buildings as displayed by the size coefficient. The interaction effect of environmental certification with building size is significant, but moves into opposite directions for rents and transaction prices, as shown in columns (3) and (6). This may perhaps reflect the fact that benefits of energy efficiency are reaped by landlords not tenants.

We also examine the effect of the energy efficiency and environmental attributes underlying environmental certification on the effective rent and transaction price of commercial buildings.

Table 5 displays certification details for the Energy Star and LEED certified buildings. The Energy Star rated buildings in the rental and transaction sample have an average rating of almost 85 points, on a 0 to 100 scale. Interestingly, Energy Star rated buildings, on average, received a rating three times, with a maximum of 14 certifications. The label vintage for Energy Star rated buildings is about one year, and the first Energy Star certification occurred in 1999.

Panel B of Table 5 shows that 82% of the 828 LEED certified office buildings in our rental sample are certified under the LEED for Existing Buildings program, as compared to 65% of the 195 LEED certified buildings included in the transaction sample. The programs Core and Shell and New Construction together account for the remaining 18% and 35% of the LEED sample, respectively.[17] The average LEED score for certified buildings in the rental and transaction sample is 53 and 55 points, on a 0 to 100 scale. The different categories show that the buildings in our sample score highest on "Innovative Design" and "Indoor Environmental Quality." The vintage for LEED certification is higher than for the Energy Star rated buildings, with an average of 2.1 years for the rental sample and 1.7 years for the transaction sample. This can be explained by the fact that LEED certified buildings are less frequently recertified as compared to Energy Star rated buildings.

We relate the variation in environmental attributes to rents and sales prices using the model presented in Equation (4). Table 6 presents the results of

[17] LEED for Commercial Interiors is excluded from all analyses. LEED for Commercial Interiors often affects only part of a building and is regarded as a tenant initiative. Because we observe financial information at the asset level, these tenant initiatives are not included.

Table 5 ■ Certification characteristics Energy Star and LEED.

	Rental Sample		Transaction Sample	
A. Energy Star Rated Buildings	Mean	Standard Dev.	Mean	Standard Dev.
Rating (75–100)	84.61	6.62	84.58	6.77
Number of Ratings (number)	3.25	2.32	2.74	2.08
Vintage (years)	1.06	1.53	1.04	1.47
Observations		2,755		737

	Rental Sample		Transaction Sample	
B. LEED Certified Buildings	Mean	Standard Dev.	Mean	Standard Dev.
Program (percent)				
Core and Shell	14.37		24.10	
Existing Buildings	82.37		65.13	
New Construction	3.26		10.77	
Total score (0–100)	53.03	8.72	55.05	9.44
Category (0–100)				
Energy and Atmosphere	52.48	17.73	50.85	18.76
Innovative Design	89.91	16.97	87.93	19.84
Indoor Environmental Quality	64.57	15.17	64.16	14.35
Material and Resources	43.88	18.01	48.42	20.29
Sustainable Sites	44.37	19.51	48.73	19.34
Water Efficiency	54.12	18.99	53.65	18.66
Vintage (years)	2.10	1.36	1.69	1.17
Certification Level (percent)				
Certified	15.22		13.33	
Silver	32.37		28.72	
Gold	48.07		50.77	
Platinum	4.35		7.14	
Observations		828		195

Note: All variables in percent, unless indicated otherwise. The scores for the LEED certification categories have all been rebased to reflect a 0–100 scale.

the estimation of the different environmental attributes and the effective rent per square foot (control variables are omitted from the table). Similar to the specifications described above, the models in Table 6 explain 72% of the variation in the effective rent of the office buildings in our sample.

Column (1) shows that an Energy Star rated building commands a 4.8% higher effective rent, but the vintage of an Energy Star rating has a negative impact on the certification premium. Although the label deprecation effect is not significant, the coefficient points toward the expected direction.

Column (2) investigates the impact of the rating level for Energy Star certified buildings. The rating coefficient indicates that the premium for Energy Star

Table 6 ■ Certification characteristics and effective rents (dependent variable: log of effective rent per square foot).

	(1)	(2)	(3)	(4)	(5)	(6)
Energy Star	0.048***		0.042***	0.041***	0.042***	0.044***
(1 = yes)	[0.009]		[0.008]	[0.008]	[0.008]	[0.008]
Energy Star Vintage	−0.007					
(years)	[0.004]					
Energy Star Rating		0.005***				
(0–10)		[0.001]				
LEED	0.011	0.013				
(1 = yes)	[0.014]	[0.014]				
LEED Score			0.002			
(0–10)			[0.002]			
LEED Program (1 = yes)						
Core and Shell				0.013		
				[0.037]		
Existing Buildings				0.011		
				[0.015]		
New Construction				0.110*		
				[0.066]		
LEED Certification Level (1 = yes)						
Certified					0.099***	
					[0.027]	
Silver					0.006	
					[0.024]	
Gold					−0.003	
					[0.018]	
Platinum					−0.018	
					[0.038]	
LEED Rating by Category (0–10)						
Energy and Atmosphere						−0.005
						[0.007]
Innovative Design						−0.007
						[0.006]
Indoor Environmental Quality						−0.005
						[0.008]
Materials and Resources						0.021***
						[0.007]
Sustainable Sites						−0.017***
						[0.006]
Water Efficiency						0.022***
						[0.006]
Building Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Location Clusters	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.617***	2.616***	2.616***	2.616***	2.615***	2.615***
	[0.017]	[0.017]	[0.017]	[0.017]	[0.017]	[0.017]
Observations	27,451	27,451	27,451	27,451	27,451	27,451
R^2	0.75	0.75	0.75	0.75	0.75	0.75
Adj. R^2	0.72	0.72	0.72	0.72	0.72	0.72

Note: Robust standard errors clustered for each location cluster in brackets, significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.

buildings increases with 0.05% for every one-point increase in the rating. A building with the minimum Energy Star rating of 75 points rents for 3.8% more, increasing to a rent premium of 5% for a building with the maximum rating of 100 points. In this specification, once controlling for energy performance, LEED certification does not alter the total rent increment for environmental certification.

Column (3) analyzes the relationship between the LEED score and the associated rent increment. The coefficient on the LEED score does not indicate a significant relationship between the LEED score and the effective rent premium. However, the indicator variable for an Energy Star label indicates a 4.2% premium for buildings with an Energy Star label.

Column (4) further disentangles the impact of the different LEED programs. The rent increment is highest for the New Construction program at 11%. The coefficients for the LEED for Core and Shell and LEED for Existing Buildings program are not significant, although the positive signs point toward a small premium. A potential explanation for the fact that the rent increment associated with a LEED certificate is higher for newly constructed buildings as compared to existing buildings may be the difference in what the different labels reflect. The New Construction designation can only be obtained by fundamentally changing the design and construction of a building, whereas the Existing Building designation is merely a reflection of current building performance, which is also captured by the Energy Star rating.

Column (5) displays the results for different LEED rating levels. LEED certified buildings achieve the highest rent increment, at 9.9%. The other LEED rating levels—Silver, Gold, and Platinum—do not command a significant rent premium as compared to non-certified office buildings.

Column (6) documents the impact of the different LEED credit categories on the effective rent. The categories Water Efficiency and Materials and Resources have a significant positive impact on the effective rent level, whereas each additional point in the category Sustainable Sites leads to a discount. Multiplying these effects with the average scores for each category implies that the average LEED certified building in our sample rents for 13.3% more. Importantly, this regression controls for the presence of an Energy Star rating, which may explain the insignificant results for the Energy and Atmosphere variable.

Table 7 presents the relationship between the various environmental attributes and the transaction price (control variables are omitted from the table). Similar

Table 7 ■ Certification characteristics and transaction prices (dependent variable: log of transaction price per square foot).

	(1)	(2)	(3)	(4)	(5)	(6)
Energy Star	0.111***		0.064**	0.067***	0.065**	0.065**
(1 = yes)	[0.030]		[0.025]	[0.025]	[0.025]	[0.025]
Energy Star Vintage	−0.047***					
(years)	[0.014]					
Energy Star Rating		0.008***				
(0–10)		[0.003]				
LEED	0.139***	0.145***				
(1 = yes)	[0.041]	[0.041]				
LEED Score			0.028***			
(0–10)			[0.007]			
LEED Program (1 = yes)						
Core and Shell				0.246***		
				[0.084]		
Existing Buildings				0.134***		
				[0.046]		
New Construction				−0.078		
				[0.135]		
LEED Certification Level (1 = yes)						
Certified					0.045	
					[0.097]	
Silver					0.103	
					[0.094]	
Gold					0.135***	
					[0.045]	
Platinum					0.491***	
					[0.100]	
LEED Rating by Category (0–10)						
Energy and Atmosphere						−0.011
						[0.022]
Innovative Design						−0.008
						[0.016]
Indoor Environmental Quality						0.020
						[0.027]
Materials and Resources						0.000
						[0.020]
Sustainable Sites						0.010
						[0.021]
Water Efficiency						0.021
						[0.020]
Building Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Location Clusters	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	4.152***	4.141***	4.142***	4.141***	4.141***	4.141***
	[0.190]	[0.191]	[0.191]	[0.191]	[0.191]	[0.191]
Observations	10,454	10,454	10,454	10,454	10,454	10,454
R^2	0.75	0.75	0.75	0.75	0.75	0.75
Adj. R^2	0.73	0.73	0.73	0.73	0.73	0.73

Note: Robust standard errors clustered for each location cluster in brackets, significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.

to the specifications described above, the models in Table 7 explain 73% of the variation in transaction price.

Column (1) shows that an Energy Star label commands a 11.1% transaction price premium as compared to non-labeled buildings. However, the coefficient on Energy Star vintage indicates that the premium decreases with 4.7% for every year the label ages. The average Energy Star labeled building in the transaction sample would therefore command a 6.2% transaction price increment. Office buildings with both an Energy Star and LEED certificate—this applies to 14% of the certified buildings in the transaction sample—command a transaction price premium of 20.1%.

Column (2) investigates the relationship between the Energy Star rating level and the sales price for the office buildings in the transaction sample. The rating level of an Energy Star label is significantly related to the transaction price of an office building, the transaction price increment increases with 0.08% for every one-point increase in the rating. This translates to a transaction price premium of 6% at the minimum rating level of 75 points and a premium of 8% at the maximum rating level of 100 points. A LEED certificate in addition to the Energy Star label would increase the transaction price increment with 14.5%.

Column (3) examines the effect of the LEED score on the transaction price. In contrast to the results presented in Table 6, the coefficient on the LEED score is significant, indicating a positive relationship between the transaction price and LEED score. This leads to a transaction price premium of 15.5% at the average LEED score of 55 points. The maximum LEED score of 85 points is associated with a 23.5% transaction price increment, but we do not observe many of such buildings in our sample. An Energy Star label in addition to a LEED certification further increases the transaction price premium with 6.4%.

Column (4) corroborates the findings for the rental sample that the transaction price increment for LEED for newly constructed (New Construction or Core and Shell) buildings differs significantly from the price increment for LEED for Existing Buildings. The premium for LEED for Core and Shell is highest at 24.6%, followed by a positive and significant premium of 13.4% for LEED for Existing Buildings. Given that 78% of the buildings certified under this program have an Energy Star label, this yields an additional premium of 6.7%. Buildings certified under the New Construction program do not command a price premium as compared to buildings without a LEED certificate.

Column (5) shows the results for the different LEED rating levels. Contrasting the findings for the rental sample, a higher LEED certification level is associated with a higher transaction price. Whereas buildings that are LEED certified or LEED Silver do not sell for more, buildings with the certification level Gold or Platinum sell for 13.5% and 49.1% more, respectively. We note that the number of LEED Platinum buildings in our transaction sample is quite small, it is therefore possible that we observe a subset of so-called trophy buildings.[18]

Column (6) documents the impact of the different LEED credit categories on the transaction price. In contrast to our earlier findings, none of the specific categories indicate a significant relationship with the transaction price of the office buildings in our sample. The small number of LEED observations in the transaction sample might explain part of these results, or the market is simply ignorant toward the underlying environmental performance details.

Conclusion and Discussion

The durable building stock in the United States is a major consumer of energy and other natural resources. The Energy Information Agency predicts that between the years 2012 and 2040, residential electricity consumption will increase by 21%, and commercial electricity consumption will also increase by 21%.[19] This increased consumption will have significant greenhouse gas externality consequences because a large share of electricity is generated using fossil fuels such as coal and natural gas.

An ongoing policy agenda seeks to identify cost-effective climate change mitigation and adaptation strategies (Stern 2008, Konrad and Thun 2014). Environmental certification programs are a means to reduce information asymmetry, which otherwise may prevent the market from accurately pricing the energy performance of buildings. In different industries, certification and disclosure programs have proven to be effective tools for information provision.

Our work highlights the importance of focusing on commercial buildings, and the relevance of voluntary certification programs. The two most important

[18]Inspecting the individual building characteristics for these buildings confirms the notion that these are indeed high quality assets. Examples of such assets are: 101 California Street in San Francisco, 1225 Connecticut Avenue NW in Washington, D.C., and the Hyatt Center in Chicago.

[19]See pages IF-46, MT-7 and MT-9 of the U.S. Energy Information Administration's *Annual Energy Outlook 2014 With Projections to 2040*, http://www.eia.gov/forecasts/AEO/pdf/0383(2014).pdf.

national programs verifying the environmental attributes of buildings are EPA's Energy Star and USGBC's LEED program. We document that the adoption of these environmental certification schemes has increased strongly over the last decade. By 2014, almost 40% of the square footage in the 30 largest U.S. office markets had been certified under the Energy Star or LEED program. Some markets have even seemed to reach a saturation point, such as Chicago with an environmental certification adoption of 62% (measured by square footage).

With environmental building certification reaching such significant adoption levels, the implications for commercial real estate investors are becoming more important. Prior research has evaluated the financial performance of green buildings when this market was still nascent (see, *e.g.*, Fuerst and McAllister 2011, Eichholtz *et al.*, 2010, 2013), but the recent growth of voluntary adoption of environmental building certification, against the backdrop of a highly volatile commercial real estate market, yields the need for further research and insight into the financial performance of environmentally certified assets.

Using a longitudinal data set of 26,212 buildings for the seven largest metropolitan areas, we construct a set of rent indices, analyzing the annual growth in total net asking rent and effective rent of environmentally certified and non-certified commercial office buildings since 2004. The findings of the repeated rent models show that the relationship between rental performance and environmental certification is certainly dynamic, and the impact of environmental certification has changed significantly over time. Although statistically hard to assess, it seems that pre-crisis, environmentally certified buildings enjoyed stronger rental and occupancy growth, which has reversed post-crisis—non-certified buildings had a stronger rebound in the 2009–2013 period. However, the rental, occupancy and pricing *levels* of environmentally certified buildings remain significantly higher than for non-certified buildings. A propensity-weighted cross-sectional analysis shows a consistent rent and transaction price increment for Energy Star labeled and LEED certified office buildings.

Using a performance attribution analysis, we further disentangle the value determinants of environmental building certification. We document that the energy and environmental performance of commercial assets is more valuable in locations with warmer climates, and is weakly related to the level of local energy prices.

With respect to the specific certification characteristics, we document that it is not just the label that matters: the marginal rent increases with an increasing Energy Star rating or LEED score. In addition, vintage matters for Energy Star labeled office buildings. For LEED certified office buildings, we document that the marginal value of certification is higher for newly constructed buildings relative to existing buildings with a LEED certificate. The different LEED categories show that Water Efficiency, Materials and Resources, and Sustainable Sites have the largest effect on the effective rent level of the assets in the rental sample.

The findings in this article have some implications for policy makers, especially in the perspective of current policy developments. We argue that consistent provision of information to the real estate market through credible energy and sustainability labels provides a relatively low-cost strategy for differentiation in the commercial building stock. If certified office buildings rent or sell for a premium, or have a higher propensity to be leased, this encourages building owners to consider investing in increased energy efficiency. Information on the energy efficiency and sustainability of buildings in the U.S. commercial market is currently provided just for part of the building stock (designated with Energy Star or LEED labels). The mandatory disclosure of such information for the full distribution of the commercial building stock could further the understanding by private firms of the energy efficiency of their (prospective) premises, thereby reducing the information asymmetry that is presumably an important explanation for the energy-efficiency gap (Palmer and Walls 2014). An effective and cheap market signal may trigger investments in the efficiency of the building stock, with positive externality effects as a result.

CBRE Group Inc. provided financial assistance for this research. Kok is supported by a VIDI grant from the Dutch Organization for Scientific Research (NWO). We are grateful to the U.S. Green Building Council for the support in assembling the data used in the analysis. We thank Brent Ambrose, three anonymous referees, Rob Bauer, Andrea Chegut, Avis Devine, Piet Eichholtz, David Geltner, Matthew Kahn, Thies Lindenthal, Christian Redfearn, William Wheaton as well as participants to the Maastricht University seminar series, the 2014 International AREUEA Meeting, the 2015 ARES Annual Meeting, the MIT Center for Real Estate research seminar, the USC PhD seminar and the 2016 Annual AREUEA Meeting for their helpful comments. All errors pertain to the authors.

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Appendix A: The adoption of environmental building certification in the 30 largest U.S. office markets (2014)

#	Market	% Buildings Certified (1)	% sq. ft. Certified (2)	% Buildings Energy Star (3)	% sq. ft. Energy Star (4)	% Buildings LEED (5)	% sq. ft. LEED (6)
1	Chicago	17.73	62.13	15.67	52.96	5.70	27.15
2	San Francisco	17.80	61.82	15.32	51.70	6.35	30.64
3	Minneapolis/St. Paul	22.14	56.18	20.16	50.35	6.14	27.54
4	Atlanta	26.73	53.31	23.87	44.59	7.70	23.19
5	Houston	21.33	52.80	18.10	44.67	8.40	30.06
6	Los Angeles	18.78	49.76	15.79	41.36	6.11	21.81
7	Denver	13.53	44.37	11.87	38.42	5.07	21.25
8	Washington, D.C.	15.29	41.16	11.89	31.46	7.85	23.10
9	Seattle	8.88	39.41	6.42	26.40	3.78	18.93
10	Walnut Creek	9.68	38.83	6.05	22.68	1.69	8.70
11	Miami	15.86	36.89	13.21	32.32	5.77	14.67
12	Orange County	10.59	35.81	10.00	32.16	3.15	16.82
13	Manhattan	23.69	35.69	17.45	22.57	8.79	16.15
14	Philadelphia	14.78	32.61	12.75	29.18	2.31	3.74
15	Boston	8.98	31.02	7.17	23.48	3.03	14.13
16	Portland	9.91	30.71	7.06	24.71	4.33	12.84
17	Dallas/Ft. Worth	11.71	30.34	10.11	25.19	3.14	10.05
18	Sacramento	11.23	29.03	8.26	22.03	3.84	9.95
19	San Diego	7.90	28.75	6.18	23.41	3.45	15.47
20	Tampa	6.33	27.70	5.64	25.55	1.96	9.85
21	Phoenix	8.15	27.68	6.68	23.36	3.01	9.42
22	San Jose	10.11	26.87	5.47	12.28	5.05	15.65
23	Milwaukee	2.69	16.44	2.18	10.33	0.62	8.15
24	Baltimore	7.34	16.35	1.63	4.83	5.59	11.49
25	New Jersey	13.47	16.04	10.67	12.17	4.27	5.99
26	Detroit	5.00	13.07	4.32	11.57	0.95	2.26
27	Pittsburgh	1.31	11.86	0.98	9.23	0.57	6.24
28	Stamford	5.30	11.07	3.37	6.85	2.41	5.10
29	St. Louis	3.04	8.06	2.02	4.12	1.69	4.97
30	Kansas City	2.37	7.96	1.35	5.49	1.13	3.76

Note: Table A1 lists the adoption of the Energy Star rating and LEED certification program in the 30 largest U.S. office markets in 2014. Columns (1) and (2) display the number or square footage of buildings in each market that obtained an Energy Star rating, LEED certificate, or both. Columns (3) and (4) show the adoption of the Energy Star rating system, and columns (5) and (6) the adoption of the LEED certification program. All variables are in percent.

Appendix B: Environmental certification, building characteristics, rents and transaction prices (dependent variable: log of average rent, effective rent or transaction price per square foot)

	Average Rent		Effective Rent		Transaction Price	
	(1)	(2)	(3)	(4)	(5)	(6)
Green (1 = yes)	0.022***		0.046***		0.101***	
	[0.005]		[0.007]		[0.025]	
Energy Star (1 = yes)		0.015***		0.041***		0.066***
		[0.005]		[0.008]		[0.025]
LEED (1 = yes)		0.019**		0.013		0.148***
		[0.009]		[0.014]		[0.041]
Log Size	0.041***	0.040***	0.067***	0.068***	−0.011	−0.012
(thousand square feet)	[0.003]	[0.003]	[0.005]	[0.005]	[0.015]	[0.015]
Occupancy Rate	0.051***	0.051***				
(0–1)	[0.013]	[0.013]				
Building Class (1 = yes)						
Class A	0.148***	0.148***	0.172***	0.172***	0.252***	0.257***
	[0.010]	[0.010]	[0.011]	[0.011]	[0.041]	[0.041]
Class B	0.050***	0.050***	0.076***	0.075***	0.085***	0.088***
	[0.007]	[0.007]	[0.008]	[0.008]	[0.030]	[0.030]
Number of Stories (1 = yes)						
Medium (10-20)	−0.004	−0.003	0.015	0.015	−0.155***	−0.152***
	[0.008]	[0.008]	[0.010]	[0.010]	[0.024]	[0.024]
High (> 20)	−0.014	−0.013	−0.002	−0.001	−0.065*	−0.067*
	[0.009]	[0.009]	[0.011]	[0.011]	[0.037]	[0.037]
Age (1 = yes)						
≤ 10 years	0.104***	0.103***	0.096***	0.098***	0.513***	0.503***
	[0.015]	[0.016]	[0.018]	[0.018]	[0.050]	[0.050]
11–20 years	0.067***	0.067***	0.079***	0.079***	0.321***	0.319***
	[0.011]	[0.011]	[0.016]	[0.016]	[0.034]	[0.035]
21–30 years	0.027***	0.026***	−0.005	−0.005	0.163***	0.158***
	[0.010]	[0.010]	[0.012]	[0.012]	[0.032]	[0.032]
31–40 years	−0.042***	−0.042***	−0.067***	−0.067***	0.177***	0.174***
	[0.009]	[0.009]	[0.011]	[0.011]	[0.040]	[0.040]
41–50 years	0.004	0.003	0.004	0.004	−0.022	−0.025
	[0.009]	[0.009]	[0.011]	[0.011]	[0.040]	[0.040]
On-site Amenities (1 = yes)	−0.007	−0.007	0.009	0.009	0.066***	0.068***
	[0.006]	[0.006]	[0.008]	[0.008]	[0.025]	[0.025]
Location Clusters	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year Fixed Effects	No	No	No	No	Yes	Yes
Constant	2.923***	2.924***	2.618***	2.617***	4.137***	4.140***
	[0.016]	[0.016]	[0.017]	[0.017]	[0.190]	[0.191]
Observations	27,451	27,451	27,451	27,451	10,454	10,454
R^2	0.83	0.83	0.75	0.75	0.75	0.75
Adj. R^2	0.81	0.81	0.72	0.72	0.73	0.73

Note: Robust standard errors clustered for each location cluster in brackets. Significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.

Appendix C: Environmental certification, rents and transaction prices—subsamples (dependent variable: log of effective rent or transaction price per square foot)

	Class A & B		Less than 25 Years Old		Larger than 200,000 sq. ft.	
	Rent (1)	Transaction Price (2)	Rent (3)	Transaction Price (4)	Rent (5)	Transaction Price (6)
Green (1 = yes)	0.047***	0.100***	0.056***	0.080**	0.051***	0.045
	[0.007]	[0.025]	[0.017]	[0.040]	[0.013]	[0.052]
Log Size	0.067***	−0.009	0.075***	−0.011	0.043***	0.022
(thousand square feet)	[0.005]	[0.016]	[0.016]	[0.034]	[0.011]	[0.047]
Building Class (1 = yes)						
Class A	0.097***	0.165***	0.218***	0.112	0.044	0.701***
	[0.007]	[0.023]	[0.081]	[0.122]	[0.031]	[0.130]
Class B			0.170**	0.055	−0.053*	0.388***
			[0.077]	[0.108]	[0.030]	[0.123]
Number of Stories (1 = yes)						
Medium (10−20)	0.014	−0.154***	0.034	−0.105**	−0.109**	−0.251
	[0.010]	[0.025]	[0.033]	[0.049]	[0.055]	[0.218]
High (>20)	−0.001	−0.063*	−0.071*	0.081	−0.138***	−0.032
	[0.012]	[0.038]	[0.041]	[0.086]	[0.052]	[0.213]
Age (1 = yes)						
≤ 10 years	0.096***	0.512***	0.121***	0.286***	0.167***	0.512***
	[0.019]	[0.051]	[0.026]	[0.060]	[0.036]	[0.111]
11–20 years	0.079***	0.320***	0.129***	0.040	0.129***	0.488***
	[0.016]	[0.035]	[0.021]	[0.048]	[0.030]	[0.084]
21–30 years	−0.005	0.162***			−0.006	0.251***
	[0.012]	[0.033]			[0.021]	[0.076]
31–40 years	−0.067***	0.175***			−0.079***	0.337***
	[0.011]	[0.041]			[0.019]	[0.094]
41–50 years	0.005	−0.025			0.022	0.082
	[0.011]	[0.041]			[0.021]	[0.080]
On-site Amenities (1 = yes)	0.008	0.064**	0.011	−0.005	−0.001	0.018
	[0.008]	[0.026]	[0.023]	[0.062]	[0.014]	[0.049]
Location Clusters	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year Effects	No	Yes	No	Yes	No	Yes
Constant	2.695***	4.207***	2.453***	4.755***	3.009***	3.293***
	[0.020]	[0.196]	[0.087]	[0.272]	[0.081]	[0.415]
Observations	22,004	7,211	4,642	2,200	5,658	1,655
R^2	0.75	0.75	0.81	0.88	0.83	0.81
Adj R^2	0.72	0.72	0.66	0.81	0.76	0.71

Note: Robust standard errors clustered for each location cluster in brackets. Significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.