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

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Abstract

A significant part of the global carbon externality stems from buildings. 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 percent 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 percent in 2005. Tracking the rental growth of some 26,000 office buildings, we then 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 climatic 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.

Keywords: Commercial real estate, energy efficiency, sustainability, repeated measures regression, performance attribution.

JEL Codes: Q20, Q40, R33

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 percent of total U.S. energy demand in 2014.[1] Awareness of the importance of energy efficiency in buildings has been created through, for example, federal programs such as the Environmental Protection Agency's (EPA) Energy Star, 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, for example through certification.

The effects of certification and quality disclosure as tools for information provision have been documented quite extensively.[2] 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.

Analogous to the hygiene quality grade cards in Los Angeles' restaurants, Bollinger et al. (2011) examine the impact of mandatory calorie postings in chain restaurants. The authors document that the average calories per transaction decrease by 6 percent after introduction of the law in NYC in April 2008. The effect is almost entirely related to

[1] More specifically, statistics from the U.S. Energy Information Administration indicate that commercial buildings consumed 35 percent of electricity and 18 percent 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.

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

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, although revenue increases by 3 percent in case of nearby competition.

For the automotive industry, Sexton and Sexton (2014) document that consumers are willing to pay several thousand dollars more for vehicles that are perceived as environmentally friendly. The authors 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. The authors conclude that such forms of "conspicuous consumption" may improve social welfare by moving towards optimal levels of environmental protection.

For the commercial real estate industry, building certificates for energy or environmental performance were 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 U.S. or an Energy Performance Certificate in Europe. Labels providing information on the environmental characteristics of a product were first introduced in the market for consumer appliances and goods. However, whereas purchasing home appliances or consuming a meal at a restaurant are relatively small, short-term investments, 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 for the financial performance of commercial buildings.[3] Palmer and Walls (2014) document that

[3]See for example, Chegut et al. (2014), Eichholtz et al. (2010, 2013), Fuerst and McAllister (2011), and Wiley et al. (2010).

requirements of energy performance disclosure as part of city and statewide legislation are increasing. This implies that the adoption and disclosure of "green" building certificates is slowly transforming from voluntary to mandatory. Moreover, since corporate users increasingly place importance on occupying environmentally certified space, 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 et al., 2016).

This paper investigates the adoption and financial implications of environmental certification in the real estate market. First, we explore the diffusion of environmental certification in the commercial real estate sector – over space and time. We document that in the 30 largest MSAs, the average share of environmentally certified space has increased from a mere 4.6 percent in 2005 to 38.6 percent at the end of 2014. We then construct rent indices for environmentally certified and non-certified buildings, using a panel dataset of 25,690 U.S. commercial office 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.

Of course, the finding of similar rental *growth* does not preclude a significant difference in price, rent, or occupancy *levels*. Therefore, employing a cross-section of 39,236 U.S. office buildings – assessed in Q3 2013 – we estimate a performance attribution model to examine 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 rental rates and transaction prices. Importantly, the analysis documents that there is significant heterogeneity in the marginal effect of environmental building certification: local climate conditions, local electricity prices and certification levels and scores strongly influence the marginal rents and transaction prices achieved in certified buildings. These findings further our understanding of the market dynamics and underlying elements of building certification that ultimately affect the 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 paper 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 paper ends with a conclusion and discussion of the environmental implications.

Environmental Certification in Commercial Real Estate

There are two main programs in the U.S. that currently assess commercial building energy and environmental performance: EPA's Energy Star program and the United States 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 non-profit organization, developed the LEED rating system.[4] 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 lifecycle. 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

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

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 just on energy consumption. The Energy Star program started out as a voluntary program to promote the energy efficiency of consumer products and home appliances. The program includes real estate since 1995, and certification of buildings 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 percent of all buildings 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 some 1.6 billion square feet of office space have received some form of LEED certification.[5] Additionally, 10,260 office buildings, representing some 2.3 billion square feet of office space, have been awarded an Energy Star label, denoting the top energy performers among their peer set.[6]

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 U.S. 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

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

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

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.[7]

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 1.1 percent at the end of 2005, the adoption numbers show that at the end of 2014, some 12.1 percent of the commercial building stock obtained an Energy Star label or LEED certification. Measured by size, the amount of certified commercial space has increased from 4.6 percent in 2005 to 38.6 percent 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.

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 is slowing down in the most recent years (by design, only 25 percent of the market can be awarded an Energy Star label). The diffusion of LEED, however, increased rapidly from 2009 onwards and only recently shows 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 Table A1 shows that the leading markets in terms of green building adoption, as measured by the percentage of square footage, are San Francisco and Chicago, with 70.9 percent and 64.7 percent certified respectively, whereas St. Louis and

[7] 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.

Kansas City have a coverage of 6.6 percent and 9.1 percent of their commercial office market.

— Figure 1 —

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 a saturation point. 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 may start 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. returns), we construct a series of rent indices. We apply a repeated measure regression methodology, similar to the method employed by Ambrose et al. (2015), An et al. (2016), and Eichholtz et al. (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.[8] Since 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:

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

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

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 heteroscedasticity robust and clustered at the zip code level. The repeated measures rent index is estimated as follows:

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

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 the U.S. commercial office market from CoStar. CoStar Property is the 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 performance attribution analysis in Section 4, 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 section 2, 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 metropolitan statistical areas: Atlanta, Chicago, Denver, Houston, Los Angeles, New York, San Francisco, and Washington D.C. These areas are the largest commercial office markets in the U.S. Moreover, these markets provide for geographical 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 the building information from CoStar, based on location. The certification information is matched to building information using the longitudes and latitudes 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 these "stale" observations reduces the total sample to 26,876 observations, 2,002 of which are certified.[9]

In addition, following An et al. (2016) we exclude buildings for which the average change in the quarterly rental rate is smaller than minus 50 percent or larger than 50 percent, in order to remove erroneous information. This exercise reduces the sample to 25,690 buildings, of which 1,832 are certified. In total, we observe 268,617 quarterly records for 25,690 buildings, with an average of more than ten observations per building.

[9] 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 almost 39 percent, 87 percent of the identified certified buildings remain in the final sample.

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 no longer classify the building as certified and it returns to the non-certified part of the sample.[10]

Descriptive Statistics

Panels A to C of Figure 2 show how the variables of interest develop over time (note that these are simple, non-parametric comparisons). Panel A shows the average total net asking rent for the certified buildings 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 15 percent this increases to more than 30 percent 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 seven percent lower than for certified buildings. However, in contrast to the trend we observe in the total net asking rent, this difference is slightly decreasing over time. While the average difference in occupancy rate in 2004 is more than seven percent, this is reduced to less than five percent 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 between certified and non-certified buildings is almost 29 percent and is increasing over time.

— Figure 2 —

[10]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 Section 2.

Environmental Certification Indices

The results of the indices estimated in Equation (3) are graphically presented in Figure 3. The solid black line depicts the index for the certified buildings in our sample and the solid gray line provides the index for non-certified buildings. The dashed lines represent the 95 percent confidence interval for both indices. The base quarter is Q1 2004. Although data is available for earlier quarters, the limited amount of certified buildings at the beginning of the 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 the certified and non-certified buildings does not differ significantly throughout the sample period, as displayed by the confidence intervals. 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 observed.

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.[11] 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 13.2 percent, as compared to 8.5 percent for non-certified assets. Interestingly,

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

the non-certified index surpasses the certified index at the end of the sample period. The overall difference in growth over the sample period is relatively small 1.6 percent over almost 10 years. Whereas certified assets experience a total rental growth of 21.2 percent, the total growth for non-certified assets is 23.8 percent. These results suggest that the difference in rental rate levels between certified and non-certified assets is decreasing (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. 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 14.9 percent. At the peak of the market, based on the estimated indices, this was 19.3 percent. The difference in effective rental growth between the certified and non-certified buildings at the end of the sample period decreased to 9.2 percent (over a ten year period).

— Figure 3 —

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

— Table 1 —

Previous studies have documented a significant difference in rents and occupancy rates of certified buildings, but focus typically on a single point in time (Chegut et al., 2014; Eichholtz et al., 2010, 2013; Fuerst and McAllister, 2011). 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 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 in the form of a hedonic pricing model to investigate the average marginal pricing effect for environmentally certified buildings and the heterogeneity of this effect (Rosen, 1974). Specifically, we use a semi-log 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:

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

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, etc.) 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 et al. (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.[12] 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 energy prices, climate conditions, walkability of the location 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 geographic 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 Eq. (4), further disentangling the "certification" indicator by its underlying attributes, such as labeling level, efficiency score, etc.

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 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. To alleviate concerns about unobservables, we apply propensity score

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

weighting throughout all analyses, in order to further account for the differences between "treated" certified buildings and "untreated" non-certified buildings.

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. national commercial office market, included in the CoStar universe as of Q3 2013, and has information on the rent level as well as the last recorded transaction price of the asset. The information in the CoStar database is 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 office buildings. For a building to be included in the analysis, complete information needs to be available for all quality characteristics. In addition, the final sample only includes locational clusters with at least one environmentally certified and one non-certified building. These restrictions lead to a rental sample of 27,829 office buildings, 2,772 of which have an Energy Star rating and 834 are certified under the LEED program (574 buildings have obtained both ratings). The transaction sample includes a total of 11,603 office buildings, 777 of these assets are Energy Star rated and 306 hold a LEED certification (229 buildings obtained both ratings). The transaction sample spans the time period from Q1 1999, when the Energy Star and LEED certification were introduced, to 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 percent occupied. The effective rent for non-certified office buildings is about 24 dollar per square foot. The average office spans some 132,000 square feet, divided over ten stories. With respect to building quality, almost 60 percent of the buildings are designated as quality Class B with approximately even distributions for Class A and Class C buildings. The average commercial building in the sample is almost 37 years old, and 40 percent of the buildings are renovated.[13] On-site amenities are present for 17 percent of the buildings.[14]

The comparison between non-certified and environmentally certified buildings shows some interesting differences. Whereas almost 70 percent of the certified office buildings are classified as Class A, just 20 percent of the non-certified buildings achieve this rating. The difference in Class B buildings is the reverse; only 31 percent of the certified buildings have this rating, as compared to 57 percent of the non-certified buildings. Virtually no certified buildings are designated as Class C, whereas 22 percent of the non-certified buildings fall into this category. Certified office buildings are on average more than 15 years younger than non-certified office buildings, and not surprisingly, certified buildings are less often renovated. On-site amenities are present in 42 percent of the certified office buildings. Interestingly, the average Walkscore for certified buildings is lower compared to the Walkscore for non-certified buildings.[15]

— Table 2 —

[13]In this specification we define age relative to the year of construction or the year of the last major renovation.

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

[15]Due to the construction of location clusters with a quarter mile radius for each certified building we may observe non-certified buildings multiple times. To some extent this may explain the higher average Walkscore for non-certified buildings as compared to certified office buildings.

Empirical Results – Marginal Effects

Table 3 presents the results of estimating Eq. (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 68 and 78 percent of the variation in the dependent variable.[16]

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 impact on the rental level. Compared to a Class C building a Class A building commands a 13.2 percent premium. The rental increment for a Class B building is 4.2 percent. Interestingly, the Walkscore as an additional measure of location quality is negatively related to the average weighted rent of an office building, although this effect is small. This is in contrast with the effects documented by Pivo and Fisher (2011), who document a 0.9 percent increase in market value and a 0.7 percent increase in net operating income for a one-point increase in the Walkscore of office buildings. 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 et al. (2013).

Energy Star or LEED certified buildings command a rent premium of 2.5 percent. 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 94,000 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 percent more than non-rated buildings; the

[16] A table displaying the full results including all building characteristics in the specifications is in Appendix B.

rent increment for LEED certified office buildings is slightly higher, at 2.3 percent. In case an office building has achieved both certifications, the aggregate rent premium is 3.8 percent. This holds for about 19 percent 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 5.2 percent higher effective rent as compared to non-certified buildings. The average non-certified building in our sample would extract about USD 167,000 in additional cash flow per year if it were certified. Applying a capitalization rate of 4.4 percent, this translates to an increase in market value of some USD 3.8 million.[17] The impact of an Energy Star rating is 3.8 percent; LEED certified buildings have a 3.4 percent higher cash flow. The combined effect of an Energy Star and LEED certification is 7.2 percent. 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 are leased for more.

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. In contrast to the findings for the rental sample, the Walkscore associated with a building or location is not significantly related to the transaction price. Large buildings sell for less, in relative terms, as indicated by the negative coefficient on building size.

Buildings with either an Energy Star or LEED certificate transact for 14.4 percent more as compared to non-certified buildings. This implies a price premium of almost USD 4.4 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

[17] 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`.

column (6) shows that Energy Star rated buildings transact for 10 percent more, while a LEED certificate commands an 18.9 percent premium, on average.

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

— Table 3 —

Empirical Results – Heterogeneous Effects

Table 4 presents a set of models investigating the interaction between environmental certification and climate, energy price, location and size effects, to distinguish between the energy efficiency and environmental aspects of certification, and other heterogeneous effects. Monthly heating and cooling degree day information is collected for all weather stations in the U.S. from the National Oceanic and Atmospheric Administration from January 1999 to December 2013. This information is then matched to the observations in both samples based on the geographically nearest weather station and the month of observation. Monthly electricity prices at the county level are retrieved from the Energy Information Administration 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 monthly degree days with environmental certification. The results show that environmentally certified office buildings in more extreme climates are more valuable as compared to certified office buildings in more moderate climates. At the average temperature level, the certification premium is 4.2 and 7.1 percent for the rental and transaction sample, respectively. However, a one standard deviation (some 153 and 265 degree days for the rental and transaction sample, respectively) increase in degree days increases the certification premium by 2.3 and 5.3 percent, respectively.

Including the impact of local electricity prices, measured at the county-month level, in columns (2) and (5) indicates that, although the premium for environmental certification is higher for buildings in locations with more extreme climates, higher electricity prices have a slightly negative impact on the increment of value of environmental certification. At the point of means, this implies an average environmental certification premium of 3.1 and 6.3 percent for the rental and transaction sample respectively, which increases with an increase in the monthly degree days and decreases with increasing electricity prices. This result contrasts findings by Kahn and Kok (2014) who study the impact of environmental certification in the California housing market (of course, unobservables related to both locational variation in energy prices and to real estate markets may explain this effect).

Columns (3) and (6) examine the relationship between location quality and environmental certification, using the Walkscore as a proxy for location quality. Interestingly, the interaction effects for the rental and transaction sample move in opposite directions: environmentally certified buildings in a highly walkable location rent for less but transact for more.[18] A one-point increase in the Walkscore yields a 0.09 percent discount in the rental sample and a 0.30 percent premium in the transaction sample. Of course, the effective rent is a reflection of a single point in time (Q3 2013), whereas sales prices are measured over a larger sample period. This result may also be related to current market dynamics on environmental certification: premiums may be more pronounced in generally less walkable cities, such as Dallas, Phoenix, and San Antonio, where supply of certified space is still low relative to, for example, more walkable cities like Boston, New York, and San Francisco.[19]

— Table 4 —

[18]The overall effect is stable to alternative definitions of location quality where we employ different cut-off values for the Walkscore to create an indicator variable.

[19]These examples are based on the 2016 Walkscore ranking for cities with more than 750,000 inhabitants. Retrieved from: `www.walkscore.com/cities-and-neighborhoods`.

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 fourteen 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 percent of the 832 LEED certified office buildings in our rental sample are certified under the LEED for Existing Buildings program, as compared to 65 percent of the 201 LEED certified buildings included in the transaction sample. The programs Core and Shell and New Construction together account for the remaining 18 percent and 35 percent of the LEED sample, respectively.[20] The average LEED score for certified buildings in both 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 than Energy Star rated buildings.

— Table 5 —

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

[20]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. Since we observe financial information at the asset level, these tenant initiatives are not included.

Table 6 explain some 70 percent of the variation in the effective rent of the office buildings in the rent sample.

Column (1) shows that an Energy Star rated building commands a 4.6 percent higher effective rent, but the vintage of an Energy Star rating has a significantly negative impact on the certification premium. On average, the premium for an Energy Star rated building decreases with 0.8 percent for every year the rating ages.

Column (2) investigates the impact of the rating level for Energy Star certified buildings. The rating coefficient indicates that the premium for Energy Star buildings increases with 0.04 percent for every one-point increase in the rating. A building with the minimum Energy Star rating of 75 points rents for 3 percent more, increasing to a rent premium of 4 percent for a building with the maximum rating of 100 points. Buildings with both an Energy Star and LEED certificate command a 3.3 percent higher rent in addition to the Energy Star premium.[21]

Column (3) analyzes the relationship between the LEED score and the associated rent increment.[22] The coefficient on the LEED score indicates that a one-point increase in the LEED score yields a 0.5 percent increase in the rent premium. This implies a rent increment of 1.8 percent at the minimum LEED score. At the average score of 53 points the rent increment associated with a LEED certification is 2.7 percent. Moreover, the indicator variable for an Energy Star label indicates an additional 3.9 percent premium for buildings with both certifications.

Column (4) further disentangles the impact of the different LEED programs. The rent increment is highest for the New Construction program at 12.3 percent. Buildings certified under the LEED for Core and Shell program command a 8.2 percent premium in effective rent. The rent premium for LEED for Existing Buildings is just 2.5 percent, although insignificant. However, most of the buildings certified under the LEED for Ex-

[21] In an alternative specification, Energy Stare rating squared is included to examine a possible non-linear relationship between the rent increment and the Energy Star rating. The coefficient on this variable is not significant, although the negative coefficient points in the expected direction.

[22] We also include LEED score squared in an alternative specification to examine the potential non-linear relationship between the LEED score and the effective rent level. The coefficient on this variable is not significant, although the negative coefficient points in the expected direction.

isting Buildings program have an Energy Star label as well – this holds for 79 percent of the observations – the total rent premium for such buildings is 3.9 percent. We explain the fact that the rent increment associated with a LEED certificate is higher for newly constructed buildings as compared to existing buildings by 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 premium, at 9.4 percent. The other LEED rating levels – Silver, Gold, and Platinum – do not command a significant rent premium as compared to non-certified office buildings, although the positive coefficients point towards the expected direction.

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 9.5 percent 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 6 —

Table 7 presents the relationship between the various environmental attributes and the transaction price (control variables are omitted from the Table). Similar to the specifications described above, the models in Table 7 explain some 68 percent of the variation in transaction price.

Column (1) shows that an Energy Star label commands a 15.1 percent transaction price premium as compared to non-labeled buildings. However, the coefficient on Energy Star vintage indicates that the premium decreases with 5.7 percent for every year the label ages. The average Energy Star labeled building in the transaction sample would therefore command a 9.4 percent transaction price increment. Office buildings with both an Energy Star and LEED certificate – this applies to 27 percent of the certified buildings in the transaction sample – command a transaction price premium of 18.1 percent.

Column (2) shows the relationship between the Energy Star rating level and the sales price for the office buildings in the transaction sample. The premium associated with an Energy Star label increases with 0.12 percent for every one-point increase in the rating. This effect is slightly larger as compared to the results for the rental sample. On average, an Energy Star labeled office building commands a 9 percent price premium with a maximum premium of 12 percent for a building with 100 points. A LEED certificate in addition to the Energy Star label would increase the transaction price increment with 18.9 percent.

Column (3) examines the effect of the LEED score on the transaction price. The coefficient on LEED score indicates that a one-point increase in the rating yields a 0.36 percent increase in the transaction price, implying that the average LEED certified building with a rating of 55 would sell for 19.8 percent more compared to an otherwise similar office building without a LEED certification; the maximum LEED score observed in the transaction sample of 84 points is associated with a 30.2 percent premium, 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 10 percent.

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 29.3 percent, followed by a positive and significant premium of 17.1 percent for LEED for Existing Buildings. Given that 78 percent of the buildings certified under this program have an Energy Star label, this yields an additional premium of 10.4 percent. Buildings certified under the New Construction program do not command a price premium as compared to buildings without a LEED certificate, although the positive coefficient points in the expected direction.

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 do not sell for more, buildings with the certification level Silver or Gold sell for 15.8 and 18.5 percent more, respectively. The premium for buildings with a LEED Platinum certificate is 48.6 percent. 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.[23]

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 ignorant towards the underlying environmental performance details.

— Table 7 —

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 percent, and commercial electricity consumption will also increase by 21 percent.[24] This increased consumption will have significant greenhouse gas externality consequences since a large share of electricity is generated using fossil fuels such as coal and natural gas.

[23] Inspecting the individual building characteristics for these buildings confirms the notion that these are very high quality assets. Examples of such assets are: 101 California Street in San Francisco, the LA Tower at 400 South Hope Street in Los Angeles or the Hyatt Center in Chicago.

[24] 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`.

An ongoing policy agenda seeks to identify cost-effective climate change mitigation and adaptation strategies (Konrad and Thun, 2014; Stern, 2008). 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 national programs verifying the environmental attributes of buildings are EPA's Energy Star and USGBC's LEED programs. We document that the adoption of these environmental certification schemes has increased strongly over the last decade. By 2014, almost 40 percent 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 San Francisco with an environmental certification adoption of almost 71 percent (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 for example, Eichholtz et al., 2010, 2013, and Fuerst and McAllister, 2011), but the recent growth of voluntary adoption of environmental building certification, against the backdrop of a highly volatile commercial real estate market, yield the need for further research and insight into the financial performance of environmentally certified assets.

Using a longitudinal dataset of 25,690 buildings for the seven largest U.S. CBSAs, 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 2009-2014 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 more extreme climates, but unrelated to 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 0.04 percent for each one-point increase in the rating of Energy Star certified buildings, and vintage matters. 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 paper have some implications for policy makers. Credible energy and sustainability labels provide 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.

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Appendix A

Table A1
The Adoption of Environmental Certification in Buildings
30 Largest U.S. Office Markets
(2014)

#	Market	% Buildings Certified (1)	% SF Certified (2)	% Buildings Energy Star (3)	% SF Energy Star (4)	% Buildings LEED (5)	% SF LEED (6)
1	San Francisco	18.89	70.85	15.17	50.53	7.92	39.94
2	Chicago	17.94	64.68	15.33	51.11	7.22	38.28
3	Minneapolis/St. Paul	22.79	63.38	19.95	49.43	7.03	34.33
4	Houston	22.62	60.27	17.61	42.50	8.34	31.00
5	Atlanta	28.16	58.87	23.43	41.75	8.80	26.62
6	Los Angeles	18.45	49.97	14.88	37.16	6.96	28.91
7	Denver	13.83	46.91	11.04	35.84	5.73	25.31
8	Washington, D.C.	15.57	42.23	11.53	29.85	8.26	25.02
9	Seattle	8.44	39.26	6.36	25.61	3.77	22.11
10	Walnut Creek	9.56	39.01	6.05	22.60	4.46	18.65
11	Orange County	10.81	38.76	10.00	33.30	3.58	18.97
12	Miami	15.62	36.83	12.73	30.18	5.67	16.25
13	Manhattan	23.18	35.25	16.94	22.18	9.81	19.03
14	Philadelphia	14.32	31.62	12.66	28.37	2.31	6.92
15	Portland	9.78	31.29	7.55	25.43	4.21	13.80
16	Tampa	6.56	31.23	5.64	25.99	2.07	11.67
17	Dallas/Ft. Worth	11.53	31.08	9.93	24.46	3.54	12.57
18	Sacramento	11.14	30.28	7.97	20.91	4.74	14.81
19	Phoenix	8.39	29.23	6.52	22.43	3.41	12.03
20	San Diego	7.72	29.16	6.00	21.90	3.38	16.66
21	Boston	8.76	29.06	6.96	22.53	3.00	13.35
22	San Jose	10.11	27.37	5.47	11.79	5.13	14.94
23	Baltimore	7.45	17.59	1.63	4.79	5.94	13.35
24	Milwaukee	2.59	16.60	2.18	10.10	0.63	8.72
25	New Jersey	13.47	16.03	10.53	12.00	4.40	6.73
26	Detroit	4.86	12.63	4.32	11.55	0.81	1.81
27	Stamford	5.30	11.04	3.37	6.85	2.66	6.26
28	Pittsburgh	1.06	9.89	0.82	7.84	0.41	4.15
29	Kansas City	2.37	9.11	1.35	5.41	1.02	3.73
30	St. Louis	2.70	6.56	2.02	4.10	1.53	4.08

Notes: 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

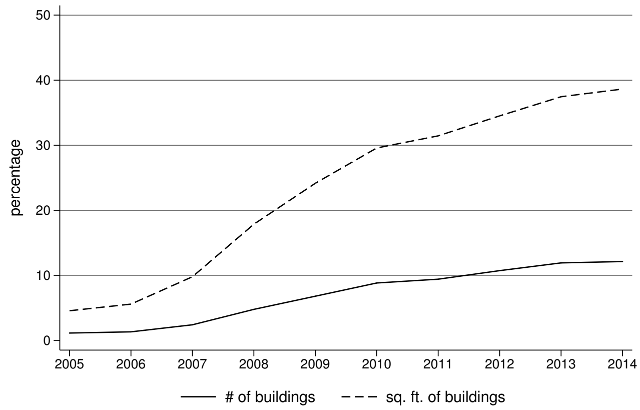
Table B1
Environmental Certification, Building Characteristics, Rent and Transaction Price (dependent variable: log of average rent, effective rent, or transaction price per square foot)

	Average Rent		Effective Rent		Transaction Price	
	(1)	(2)	(3)	(4)	(5)	(6)
Green (1=yes)	0.025***		0.052***		0.144***	
	[0.005]		[0.007]		[0.026]	
Energy star (1=yes)		0.015***		0.038***		0.100***
		[0.006]		[0.008]		[0.028]
LEED (1=yes)		0.023**		0.034**		0.189***
		[0.010]		[0.014]		[0.049]
Log size	0.044***	0.044***	0.070***	0.071***	−0.101***	−0.101***
(thousand square feet)	[0.003]	[0.003]	[0.004]	[0.004]	[0.015]	[0.015]
Occupancy rate	0.048***	0.049***				
(0-1)	[0.012]	[0.012]				
Building class (1=yes)						
Class A	0.132***	0.132***	0.134***	0.134***	0.534***	0.536***
	[0.009]	[0.009]	[0.011]	[0.011]	[0.052]	[0.052]
Class B	0.042***	0.042***	0.052***	0.052***	0.227***	0.230***
	[0.008]	[0.008]	[0.009]	[0.009]	[0.038]	[0.038]
Number of Stories (1=yes)						
Medium (10-20)	−0.018***	−0.018***	−0.011	−0.012	−0.021	−0.025
	[0.005]	[0.005]	[0.008]	[0.008]	[0.033]	[0.033]
High (>20)	−0.026***	−0.027***	−0.024**	−0.025**	0.092**	0.083**
	[0.008]	[0.008]	[0.011]	[0.011]	[0.041]	[0.040]
Age (1=yes)						
$\leq$ 10 years	0.091***	0.091***	0.098***	0.098***	0.381***	0.379***
	[0.008]	[0.008]	[0.009]	[0.009]	[0.033]	[0.033]
11 to 20 years	0.056***	0.056***	0.088***	0.087***	0.231***	0.235***
	[0.008]	[0.008]	[0.009]	[0.009]	[0.028]	[0.028]
21 to 30 years	0.059***	0.059***	0.056***	0.056***	0.205***	0.207***
	[0.007]	[0.007]	[0.008]	[0.008]	[0.030]	[0.030]
31 to 40 years	0.010	0.010	0.019**	0.019*	0.314***	0.315***
	[0.008]	[0.008]	[0.010]	[0.010]	[0.045]	[0.045]
41 to 50 years	0.054***	0.054***	0.084***	0.084***	0.231***	0.233***
	[0.010]	[0.010]	[0.012]	[0.012]	[0.060]	[0.060]
On-site amenities (1=yes)	0.006	0.006	0.012*	0.012*	0.105***	0.106***
	[0.004]	[0.004]	[0.006]	[0.006]	[0.025]	[0.026]
Walk score (0-10)	−0.010***	−0.010***	−0.010*	−0.010*	−0.014	−0.009
	[0.004]	[0.004]	[0.005]	[0.005]	[0.019]	[0.020]
Location clusters	yes	yes	yes	yes	yes	yes
Quarter-year effects	no	no	no	no	yes	yes
Constant	2.977***	2.977***	2.686***	2.686***	4.432***	4.383***
	[0.035]	[0.035]	[0.049]	[0.049]	[0.223]	[0.228]
Observations	27,669	27,669	27,669	27,669	11,567	11,567
R^2	0.80	0.80	0.73	0.73	0.71	0.71
Adj. R^2	0.78	0.78	0.70	0.70	0.68	0.68

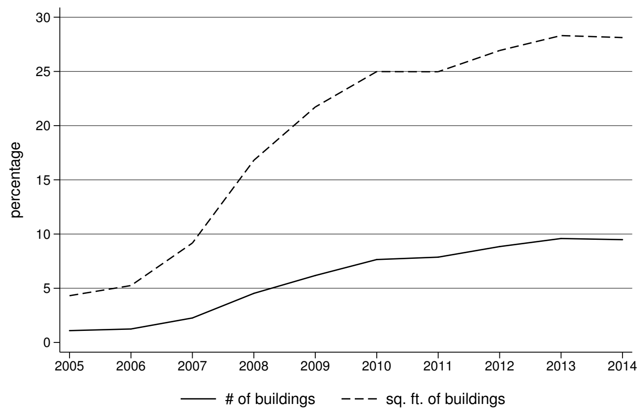
Notes: Robust standard errors clustered for each location cluster in brackets. Significance at the 0.10, 0.05 and 0.01 level is indicated by *, ** and *** respectively.

Figure 1
The Adoption of Environmental Building Certificaiton
(2005 – 2014)

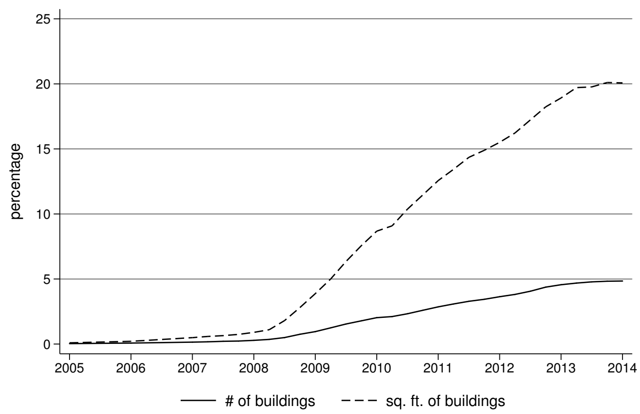
Panel A: Energy Star and Leed Adoption



Panel B: Energy Star Adoption



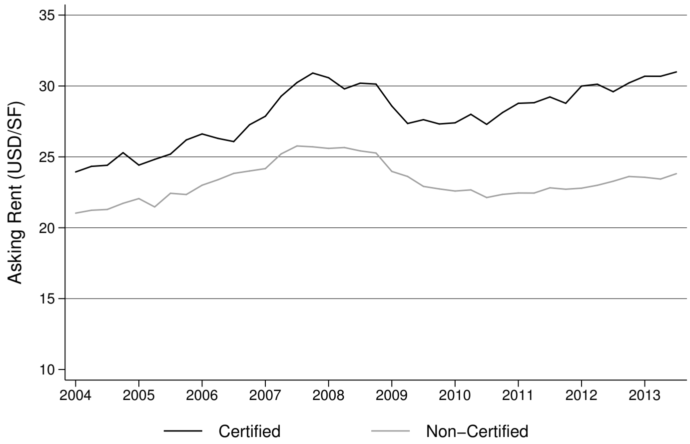
Panel C: LEED Adoption



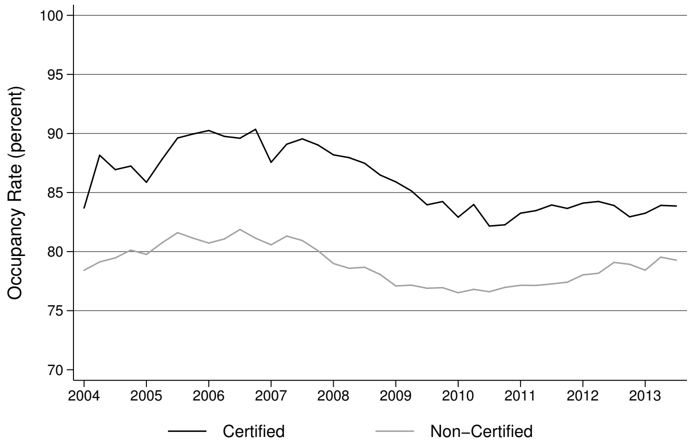
Notes: Figure 1 displays the diffusion of the Energy Star rating and LEED certification program in the 30 largest U.S. office markets over time. The adoption percentage is calculated as the number or square footage of buildings in each market having an Energy Star or LEED certification relative to the size of the market. CBREs 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.

Figure 2
Rent and Occupancy Levels
Environmentally Certified and Non-Certified Assets
(Q1 2004 – Q3 2013)

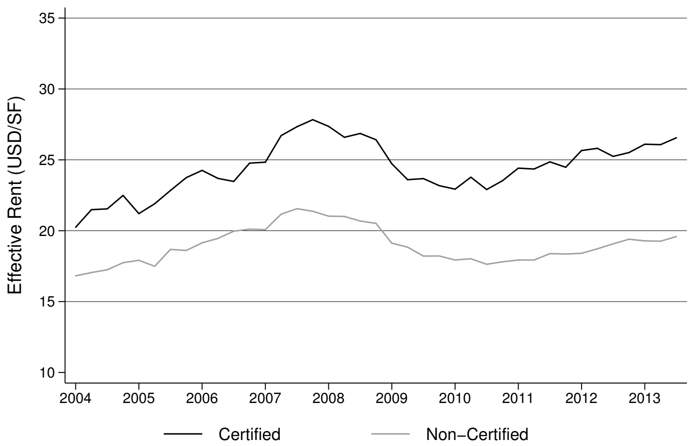
Panel A: Average Total Net Asking Rent (levels, in USD/SF)



Panel B: Average Occupancy Rate (levels, in percentage)



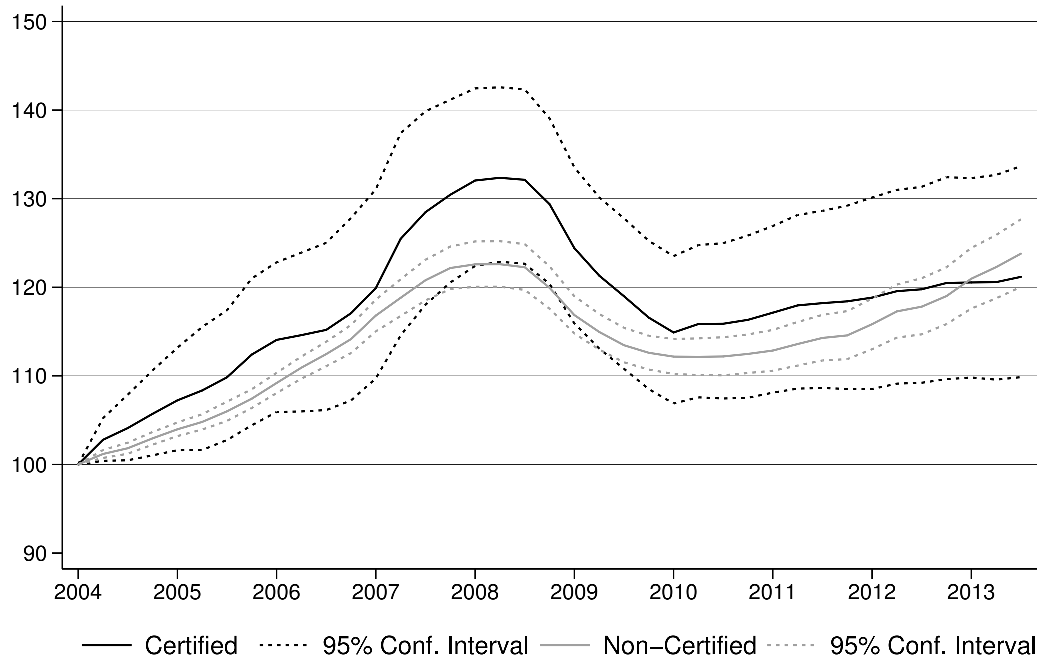
Panel C: Average Effective Rent (levels, in USD/SF)



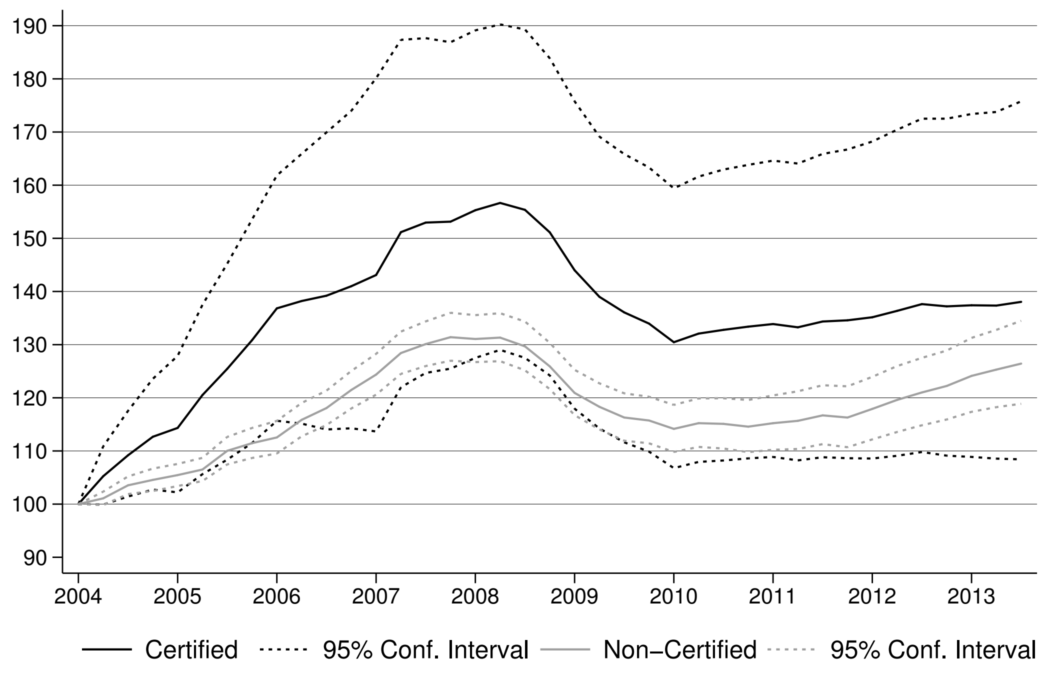
Notes: Figure 2 displays the average asking rent, occupancy rate and effective rent, respectively for environmentally certified and non-certified buildings in the repeated rent sample. The black lines represent the environmentally certified buildings, the gray lines denote the non-certified buildings.

Figure 3
Rent Indices
Environmentally Certified and Non-Certified Buildings
(Q1 2004 – Q3 2013)

Panel A: Total Net Asking Rent



Panel B: Effective Rent



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

Table 1
Environmentally Certified and Non-Certified Buidlings
Average Annual Rental Growth
(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	2.08	2.28	6.67	4.83	−1.64	0.21
	(3.16)	(2.16)	(2.08)	(1.11)	(2.63)	(2.27)
Effective Rent	3.52	2.53	10.77	6.38	−2.35	−0.68
	(4.79)	(3.23)	(3.79)	(2.15)	(3.29)	(3.09)

Notes: 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.

Table 2
Descriptive Statistics
Rent and Transaction Samples

	Rental Sample		Transaction Sample	
	Non-Certified	Certified	Non-Certified	Certified
Transaction price			286.27	265.44
(dollar per square foot)			(320.45)	(175.36)
Average weighted rent	28.47	26.44		
(dollar per square foot)	(14.62)	(10.88)		
Effective rent	24.34	22.76		
(dollar per square foot)	(14.44)	(10.85)		
Occupancy rate	83.60	85.13		
(percent)	(16.40)	(13.44)		
Size	132.02	260.11	105.62	319.37
(thousand square feet)	(201.81)	(283.32)	(241.44)	(321.29)
Building class (percent)				
Class A	21.24	68.04	13.98	71.68
Class B	56.62	30.54	51.44	27.85
Class C	22.14	1.43	34.56	0.47
Age	36.55	21.25	38.36	17.42
(years)	(30.00)	(14.23)	(35.28)	(14.15)
Age (percent)				
$\leq$ 10 years	14.43	20.42	17.19	33.02
11 to 20 years	16.36	27.42	17.13	25.85
21 to 30 years	27.51	37.00	18.95	31.61
31 to 40 years	14.24	10.15	7.96	4.94
41 to 50 years	6.36	2.55	4.44	1.41
$>$ 50 years	20.87	2.45	28.82	1.88
Stories (number)	9.53	11.81	8.08	13.83
	(8.82)	(11.69)	(9.07)	(12.49)
Stories (percent)				
Low ($\leq$10)	63.78	61.27	76.62	53.82
Medium (11-20)	26.43	22.12	15.48	21.97
High ($>$20)	9.80	16.61	7.89	24.21
Renovated (percent)	40.21	25.96	42.92	30.08
On-site amenities (percent)	16.82	41.74	9.02	42.19
Walk score	84.09	64.46	89.18	69.55
(0-100)	(22.69)	(27.57)	(19.21)	(28.76)
Observations	24,653	3,016	10,716	851

Notes: Standard deviations in parentheses. All variables in percent unless indicated otherwise.

Table 3
Environmental Certification, Rent and Transaction Price
(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)	0.025***		0.052***		0.144***	
	[0.005]		[0.007]		[0.026]	
Energy Star (1=yes)		0.015***		0.038***		0.100***
		[0.006]		[0.008]		[0.028]
LEED (1=yes)		0.023**		0.034**		0.189***
		[0.010]		[0.014]		[0.049]
Log size	0.044***	0.044***	0.070***	0.071***	−0.101***	−0.101***
(thousand square feet)	[0.003]	[0.003]	[0.004]	[0.004]	[0.015]	[0.015]
Occupancy rate	0.048***	0.049***				
(0-1)	[0.012]	[0.012]				
Building class (1=yes)						
Class A	0.132***	0.132***	0.134***	0.134***	0.534***	0.536***
	[0.009]	[0.009]	[0.011]	[0.011]	[0.052]	[0.052]
Class B	0.042***	0.042***	0.052***	0.052***	0.227***	0.230***
	[0.008]	[0.008]	[0.009]	[0.009]	[0.038]	[0.038]
Walkscore (0-10)	−0.010***	−0.010***	−0.010*	−0.010*	−0.014	−0.009
	[0.004]	[0.004]	[0.005]	[0.005]	[0.019]	[0.020]
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	2.977***	2.977***	2.686***	2.686***	4.432***	4.383***
	[0.035]	[0.035]	[0.049]	[0.049]	[0.223]	[0.228]
Observations	27,669	27,669	27,669	27,669	11,567	11,567
R^2	0.80	0.80	0.73	0.73	0.71	0.71
Adj. R^2	0.78	0.78	0.70	0.70	0.68	0.68

Notes: 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.

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	0.021	0.118***	0.064	0.082*	−0.104*
	[0.014]	[0.015]	[0.019]	[0.045]	[0.046]	[0.060]
Green * Degree days	0.015***	0.024***		0.020**	0.040***	
(monthly total)	[0.004]	[0.006]		[0.009]	[0.014]	
Green * Degree days *		−0.001**			−0.002*	
Electricity price		[0.000]			[0.001]	
Green * Walkscore			−0.009***			0.030***
(0-10)			[0.002]			[0.008]
Log size	0.070***	0.071***	0.070***	−0.101***	−0.100***	−0.101***
(thousand square feet)	[0.004]	[0.004]	[0.004]	[0.015]	[0.015]	[0.015]
Building class (1=yes)						
Class A	0.135***	0.135***	0.134***	0.532***	0.530***	0.534***
	[0.011]	[0.011]	[0.011]	[0.052]	[0.052]	[0.052]
Class B	0.052***	0.052***	0.052***	0.227***	0.226***	0.228***
	[0.009]	[0.009]	[0.009]	[0.038]	[0.038]	[0.038]
Building characteristics	yes	yes	yes	yes	yes	yes
Location clusters	yes	yes	yes	yes	yes	yes
Quarter-year effects	no	no	no	yes	yes	yes
Constant	2.599***	2.598***	2.598***	4.304***	4.303***	4.314***
	[0.017]	[0.017]	[0.017]	[0.136]	[0.137]	[0.137]
Observations	27,669	27,669	27,669	11,567	11,567	11,567
R^2	0.74	0.74	0.74	0.71	0.71	0.71
Adj. R^2	0.70	0.70	0.70	0.68	0.68	0.68

Notes: 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.

Table 5
Certification Characteristics
Energy Star and LEED

	Mean	Standard Dev.	Mean	Standard Dev.
A. Energy Star Rated Buildings	Rental Sample		Transaction Sample	
	Mean	Standard Dev.	Mean	Standard Dev.
Rating (75-100)	84.64	6.63	84.53	6.78
Number of ratings	3.26	2.32	2.73	2.06
Vintage (years)	1.06	1.53	1.05	1.46
Observations		2,757		769
B. LEED Certified Buildings	Rental Sample		Transaction Sample	
	Mean	Standard Dev.	Mean	Standard Dev.
Program (percent)				
New construction	3.37		10.95	
Core and shell	14.54		23.88	
Existing buildings	82.09		65.17	
Total score (0-100)	53.03	8.71	55.06	9.43
Category (0-100)				
Energy and atmosphere	52.43	17.74	50.96	18.63
Innovative design	89.76	17.21	88.01	19.61
Indoor environmental quality	64.51	15.17	64.27	14.25
Material and resources	43.88	17.96	48.33	20.26
Sustainable sites	44.41	19.49	48.38	19.38
Water efficiency	54.14	19.03	53.92	18.86
Vintage (years)	2.10	1.36	1.69	1.19
Certification level (percent)				
Certified	15.26		12.44	
Silver	32.33		30.85	
Gold	48.08		49.25	
Platinum	4.33		7.46	
Observations		832		201

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

Table 6
Certification Characteristics and Effective Rents
(dependent variable: log of effective rent per square foot)

	(1)	(2)	(3)	(4)	(5)	(6)
Energy star	0.046***		0.039***	0.039***	0.039***	0.041***
(1=yes)	[0.009]		[0.008]	[0.008]	[0.008]	[0.008]
Energy star vintage	−0.008*					
(years)	[0.005]					
Energy star rating		0.004***				
(0-10)		[0.001]				
LEED	0.030**	0.033**				
(1=yes)	[0.014]	[0.014]				
LEED score			0.005**			
(0-10)			[0.003]			
LEED program (1=yes)						
Core and shell				0.082**		
				[0.036]		
New construction				0.123*		
				[0.069]		
Existing buildings				0.025		
				[0.015]		
LEED certification level (1=yes)						
Certified					0.094***	
					[0.029]	
Silver					0.024	
					[0.025]	
Gold					0.021	
					[0.019]	
Platinum					0.044	
					[0.046]	
LEED rating by category (0-10)						
Energy and atmosphere						−0.007
						[0.008]
Innovative design						−0.005
						[0.006]
Indoor environmental quality						0.004
						[0.009]
Materials and resources						0.017**
						[0.007]
Sustainable sites						−0.021***
						[0.006]
Water efficiency						0.021***
						[0.007]
Building characteristics	yes	yes	yes	yes	yes	yes
Location clusters	yes	yes	yes	yes	yes	yes
Constant	2.622***	2.622***	2.622***	2.622***	2.623***	2.622***
	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]
Observations	27,669	27,669	27,669	27,669	27,669	27,669
R^2	0.73	0.73	0.73	0.73	0.73	0.74
Adj. R^2	0.70	0.70	0.70	0.70	0.70	0.70

Notes: 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.

Table 7
Certification Characteristics and Transaction Prices
(dependent variable: log of transaction price per square foot)

	(1)	(2)	(3)	(4)	(5)	(6)
Energy star	0.151***		0.100***	0.104***	0.100***	0.100***
(1=yes)	[0.034]		[0.028]	[0.028]	[0.028]	[0.027]
Energy star vintage	−0.057***					
(years)	[0.015]					
Energy star rating		0.012***				
(0-10)		[0.003]				
LEED	0.181***	0.189***				
(1=yes)	[0.049]	[0.049]				
LEED score			0.036***			
(0-10)			[0.008]			
LEED program (1=yes)						
Core and shell				0.293***		
				[0.102]		
New construction				0.103		
				[0.177]		
Existing buildings				0.171***		
				[0.054]		
LEED certification level (1=yes)						
Certified					0.040	
					[0.122]	
Silver					0.158*	
					[0.092]	
Gold					0.185***	
					[0.061]	
Platinum					0.486***	
					[0.122]	
LEED rating by category (0-10)						
Energy and atmosphere						−0.012
						[0.025]
Innovative design						−0.014
						[0.018]
Indoor environmental quality						0.042
						[0.026]
Materials and resources						−0.013
						[0.025]
Sustainable sites						0.006
						[0.022]
Water efficiency						0.028
						[0.024]
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	4.285***	4.280***	4.279***	4.280***	4.278***	4.279***
	[0.140]	[0.141]	[0.141]	[0.141]	[0.141]	[0.141]
Observations	11,567	11,567	11,567	11,567	11,567	11,567
R^2	0.71	0.71	0.71	0.71	0.71	0.71
Adj. R^2	0.68	0.68	0.68	0.68	0.68	0.68

Notes: 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.