Sustainable Building Certification and the Rent Premium: A Panel Data Approach

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Abstract

This paper investigates whether obtaining sustainable building certification entails a rental premium for commercial office buildings and tracks its development over time. To this aim, both a difference-in-differences and a fixed-effects model approach are applied to a large panel dataset of U.S. office buildings in the period 2000-2010. The results indicate a significant rental premium for both Energy Star and LEED certified buildings. Controlling for confounding factors, this premium is shown to have increased steadily from 2006-2008, followed by a moderate decline in the subsequent periods. The results also show a significant positive relationship between Energy Star labeling and building occupancy rates.

Keywords: *Rent Premium, Eco-certification, Energy Star, LEED, Panel Regression, Difference-in-Differences, Fixed-Effects, Sustainable Real Estate*

JEL codes: M14, C23, D92

1. Introduction

The emergence and rapid growth of voluntary certification systems such as Energy Star and LEED in the U.S. are reflective of a paradigm shift towards increased environmental awareness in the commercial real estate industry. The main objective of these certifications is to impart information on a building's degree of energy efficiency and sustainability to both occupiers and investors. Although environmental certification has only recently emerged from a niche market to becoming a mainstream phenomenon, a number of prominent pricing studies of *green buildings* have been conducted in the past three years. Apart from case studies of individual properties, several cross-sectional and pooled studies, which will be reviewed below, have demonstrated that certified buildings command higher rental rates compared to non-certified buildings. However, a potential shortcoming of these studies is that pricing dynamics cannot be studied in a cross-sectional framework as it only provides a snapshot of environmental labeling and certification at a certain point in time. More importantly, it is difficult to rule out in a cross-sectional study that any observed price premia were genuinely caused by eco-certification and not by unobserved pre-existing characteristics that subsequently cause both certification and higher prices.

This study takes the analysis of the effects of Energy Star labeling and LEED certification on property's rental rates and occupancy rates one step further by applying panel data regressions, specifically difference-in-differences (DID) and fixed-effects models. These models allow controlling for unobserved effects, thereby mitigating a potential omitted variable bias present in many cross-sectional studies. Fixed-effects models also provide us with an estimate of the dynamic behavior of the rent premium over time. A relatively long time series of nearly ten years of quarterly observations is used to estimate a ‘green’ rental premium index for a large sample of labeled buildings. A key expectation is that the rent premium for labeled and certified buildings has been growing over time fueled by rising concerns for the environment, higher energy prices and heightened interest in more sustainable properties. However, the sharp decline in the economy in 2007 and the following quarters may have had a dampening effect on rent premiums.

We analyze a sample of 7,140 buildings, 1,768 of which are certified and 5,372 are non-certified control buildings. The buildings are located in the 10 largest metropolitan markets across the U.S. The DID models show a significant rent premium for Energy Star from 2004 to 2007. The fixed-effects models suggest an average rent premium of 2.5% for Energy Star and 2.9% for LEED certification over the observation period. Rent premiums for Energy Star only emerge in 2006. They continuously increase until the second quarter of 2008, when the average rent premium reaches 7%, but then decrease in the wake of the economic crisis. Energy Star labels also have a significant positive effect on occupancy rates.

The remainder of the paper is organized as follows. Section two gives an introduction to the LEED certification and Energy Star labeling systems and explores how the quality of the characteristics associated with building certification may translate into higher rents. We then review the empirical and theoretical literature. Section three describes the data and model specification of the DID and panel data regressions followed by a discussion of the results. We conclude with an outlook on future research necessary for establishing a firm empirical link between sustainability and the rental value of a commercial property.

2. Background and Research Problem

In commercial real estate markets a number of voluntary labeling and certification schemes exist. The main objective of these labels and certificates is to reduce information asymmetries between landlord and tenant or seller and buyer concerning important sustainability features of a building. Each certification scheme has a particular focus on certain aspects of sustainability, be it energy efficiency, greenhouse gas emissions or sustainable materials and processes. The following section reviews the two prevailing certification systems for office buildings in the U.S., Energy Star and LEED.

2.1 Sustainable Building Certification

An obvious difference between the Energy Star and LEED certification schemes is that the former solely focuses on the energy efficiency of buildings whereas the latter encompasses a broader concept of sustainability.[1]

Energy Star is a federal program by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy and has been available for commercial buildings since 1999. The Energy Star label is awarded if a building's energy efficiency scores in the top quartile based on EPA's National Energy Performance Rating System. The energy efficiency of a building is compared to the values achieved by a group of its peers and is rated on a scale from 1-100. Buildings must earn a score of at least 75 to earn the Energy Star label. The number of Energy Star rated space has increased from 575 million square feet in 2006 to 1,400 million square feet in 2009 (Energy Star, 2009). As of April 2010, 3,847 office buildings have been Energy Star rated.

The LEED certification system was developed by the U.S. Green Building Council in 1999. This scheme awards points for satisfying specific sustainability criteria in seven categories. These categories relate to sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design, and regional priority. According to the number of points reached by a building different levels of LEED certification are conferred. For example, the four levels of LEED v3 for New Construction and Major Renovation are *certified* (40-49 points), *silver* (50-59 points), *gold* (60-69 points) and *platinum* (80 points and above). The number of LEED certified buildings has increased considerably since 2005. Data collected by the U.S. Green Building Council

(USGBC) indicate that in December 2005 a total of 468 buildings had been LEED certified and 1,903 were registered for certification. By mid-2009, 3,073 buildings had been certified and 27,066 had been registered. By April 2010, these numbers had increased to a total of 5,384 certified and 27,167 registered buildings.[2]

Empirical studies of cost premiums for construction and refurbishment report a relatively wide range of values. While most studies find a relatively low cost premium of 0 to 3% for most LEED standards (Kats, 2003, Miller et al., 2008, Matthiessen and Morris, 2007), other studies document higher costs for LEED certification, between 4.5 and 11% depending on the certification standard (Northbridge Environmental Management Consultants, 2003). However, most studies show that the reduced operating costs of the buildings more than offset the additional construction costs over the buildings' life cycle. A controversially discussed study by ConSol (2008) arrives at a less optimistic conclusion. Applying energy models to a typical suburban office building, ConSol conclude that a building specification with an energy efficiency target 30 percent better than current building codes require would not be able to recoup the cost within a 10-year period.

2.2 Advantages Ascribed to Sustainable Office Buildings

Rapid growth in both public attention and the number of certified buildings has been enhanced by the Corporate Social Responsibility (CSR) activities of large multinational corporations. Companies pursue CSR strategies for a variety of reasons. Several studies show a strong positive relationship between CSR and corporate financial performance (Orlitzky, 2003). Companies pursuing a strong CSR agenda may also be able to attract more investors and customers (Milgrom and Roberts, 1989). Within their CSR strategies, an increasing number of companies now focuses on sustainable buildings. For instance, Eichholtz et al. (2010c) identify the government, the environmentally sensitive oil industry and legal and financial services as the largest consumers of sustainable space. In addition, Pivo and McNamara (2005) report that institutional real estate investors are increasingly realizing the financial benefits associated with responsible property investing (RPI).

Tenants of sustainable space hypothetically benefit from a number of advantages. A major economic benefit of sustainable space is reduced energy use. The associated cost savings can be large if one considers that energy savings of up to 30 percent are possible for much of the commercial building stock (Kats, 2003).[3] A number of studies show that LEED certified buildings use considerably less energy than conventional buildings (Turner & Frankel, 2008, Fowler & Rauch, 2008). Other studies, however, find that the energy use of LEED certified buildings varies considerably or that these buildings do not necessarily save energy (Newsham et al., 2009, Barrientos et al., 2007, Scofield, 2009). Pivo and Fischer (2010) find that utility expenses in Energy Star buildings were 12.9% lower per square foot per year.

Further advantages include image and reputation increases for the tenants (Frombrun and Schanley, 1990), increased worker productivity and retention rates of employees, reduced staff turnover, and reduced employee absenteeism (Turban and Greening, 1997, Romm and Browning, 1998, Miller et al., 2009). Although hard to quantify and often neglected, these advantages can be of significant value to occupants as employee costs make up approximately 80 percent of the total costs of enterprises. Studies have shown that employee productivity can be increased by two to ten percent when relocating from a conventional building to a sustainable building (Lucuik, 2005). In a similar vein, Romm and Browning (1998) have shown that an increase in employee productivity by one percent can provide savings to the company that exceed their entire energy bill.

An economic advantage of sustainability for investors in commercial real estate is that sustainable buildings are likely to have longer economic lives, a lower marketability risk, and a lower risk of technical and regulatory obsolescence (Eichholtz et al., 2010a). Finally, energy-efficient buildings can insure against future energy price increases and tighter government regulations.

However, while studies across several industries have found evidence of a general willingness to pay a premium for goods and services with reduced environmental impact (Teisl et al., 2002, Maguire et al., 2004, Casadesus-Masanell et al., 2009), it should be emphasized that the existence of the benefits described above does not necessarily guarantee economic efficiency or an increase in social welfare. For example, Kotchen (2006) demonstrates that green markets can have detrimental effects on environmental quality and social welfare under certain conditions. Mahenc (2007) contends that green products are likely to be overpriced when consumers cannot ascertain the true environmental performance of a product. Producers may well take advantage of the asymmetric information by signaling a clean product and raising the price above the full information equilibrium price. This may be the case with some types of sustainable buildings where actual environmental performance is not known in advance by buyers or tenants. For example, a recent study by Scofield (2009) shows that LEED office buildings do not use less source energy (total amount of raw fuel that is required to operate the building) than comparable non-LEED buildings. Ibanez and Grolleau (2009) find that eco-labeling may achieve a positive environmental outcome, but eco-labeling alone is unlikely to be sufficient for internalizing all negative externalities.

While it is not within the scope of this study to test whether any rent premiums found in the empirical analysis are due to overpricing or do indeed reflect genuinely superior economic benefits or utility, our analysis tests whether tenants are willing to pay a premium for occupying eco-certified buildings.[4]

2.3 Market Dynamics of Sustainable Buildings

Several recent economic and societal trends appear to have favored the rise of *green buildings*. Pivo and Fischer (2010) argue that the shift in the demand for energy efficient buildings is due to the increase in energy prices since 1998. Accompanied by an increased awareness of environmental issues and tougher government regulations, sustainability has thus become an integral part of building design. An inspection of the media coverage reveals that references to the term *'Green Building'* have increased dramatically since 2005.[5] At the same time, a growing body of knowledge has emerged that emphasizes the benefits of sustainable buildings (Jones Lang LaSalle, 2008).

In the short-run, due to the construction, renovation and certification lag, the supply of eco-certified space is assumed to be inelastic. Although the number of LEED and Energy Star rated buildings has grown considerably since 2005, their share of the national office building stock is still relatively small. Figures on the proportion of eco-certified buildings in the total market differ widely. McGraw Hill Construction (2009) reports that only about 1% of buildings are certified, a more recent query of the CoStar system (January 2011) suggests that 11.8% of office space is either LEED or Energy Star rated. Regardless of the exact percentage, it is clear that demand for eco-certified space has outstripped supply in recent years which drives rent premia found in previous studies. In the medium and long run, however, supply of sustainable space is likely to increase, which may erode any fraction of the rent premium that is attributable to current excess demand. It is debatable whether the segment of state-of-the-art certified properties with the highest environmental performance will always command a premium above and beyond mere cost savings that originates from image gains and product differentiation irrespective of increased supply and market penetration levels of sustainable buildings in the future. In 2008, the sustainable market was about 10-12% of non-residential construction. Projections for the U.S. show that, in 2013, *green buildings* will make up around 20-25% of total construction (McGraw Hill Construction, 2009). This trend is reinforced by the fact that an increasing number of jurisdictions requires some degree of certification for new construction.

Apart from these demand and supply dynamics, the downturn in financial markets since 2007 has led to a sharp decrease in office rents and may also have affected rent premiums for environmental certification.[6] Although the pressure on companies to behave in a socially responsible manner is undiminished, sustainability may no longer be on top of companies' agendas as economic problems and cost-cutting measures prevail (McNamara, 2009). Kahn and Kotchen (2010), for example, find that increasing unemployment rates are associated with a reduced concern for climate change (Kahn and Kotchen, 2010). A study by Knight Frank (2008) shows that sustainable factors had fallen to last place among leasing priorities in 2008. However, surveys conducted after the onset of the financial crisis show that tenants tend to maintain their long-term sustainability commitments (Panel Intelligence, 2008). This also holds true for real estate related decisions (Jones Lang LaSalle, 2008). The time series dimension in our data will allow us to analyze how the rent premium interacts with the trends outlined above.

2.4 Existing Studies

A number of cross-sectional studies, drawing on the CoStar database, use hedonic OLS regressions to determine the rent and sales price premia associated with sustainable building certification. Miller et al. (2008) compare a filtered sample of Class A buildings to 927 certified Class A buildings while controlling for size, location, and age of the buildings. They find rent premiums for Energy Star and LEED of 6% and 10%, respectively, although these results are not statistically significant at conventional levels (Miller et al., 2008). An important limitation of this study is that it does not control for micro location effects. Wiley et al. (2010) focus on the effect of certification on asking rents, occupancy rates and sales prices in Class A buildings in 46 office markets across the U.S. They also use a hedonic OLS approach and find rent premiums of 15% to 18% for LEED and 7% to 9% for Energy Star depending on the model specification. Furthermore, 10% to 11% higher occupancy rates for Energy Star certification and 16% to 18% for LEED are found. For sale prices, the authors identify premia of $130 and $30 per sq. ft. for LEED and Energy Star, respectively. Eichholtz et al. (2010a) also use a hedonic framework to test the effect of certification on the contract rents of 10.000 office buildings, including 694 certified buildings. In order to find comparable buildings within the CoStar database they use GIS techniques with a radius of 0.25 miles around each certified building. They find a rent premium of 3.3% for Energy Star labeling. No significant rent premium is detected for LEED certification. When using effective rents instead of contract rents to control for the different vacancies in certified and non-certified buildings, they identify a rent premium of 10% for Energy Star and 9% for LEED certification. Fuerst and McAllister (2011a) use hedonic regression models and estimate a rent premium of approximately 6% for LEED certification and 5% for Energy Star while controlling for a large number of location- and property-specific factors. In a follow-up study with an updated dataset, Fuerst and McAllister (2011b) use a robust regression framework to handle influential outliers in the treatment and control samples and find a significant rental premium of 3-5% for office buildings with Energy Star or LEED certification and a 9% premium for the emerging group of dual certified buildings. However, when the authors apply a fractional logit model to the larger and updated dataset, they find only very limited support for their earlier finding of an occupancy rate premium in eco-certified buildings (Fuerst and McAllister 2009). Pivo and Fischer (2010) use the NCREIF database and identify 5.2% higher rents and 1.3% higher occupancy rates for Energy Star rated buildings.[7] Eichholtz et al. (2010b) show that the large increase in certified buildings and the recent downturn in real estate markets have not significantly affected returns of certified buildings relative to comparable buildings.

3. Data and Methodology

3.1 Data

The data used in the present study are drawn from the CoStar database and include both certified and non-certified buildings. The CoStar database includes approximately 66 billion square feet of commercial space in 2.8 million buildings, which makes it the largest real estate database for the U.S. For each building in the sample, we collect data on building-specific characteristics, historical building performance, and office market and economic data for the MSA, in which the building is located.

The data set includes all Energy Star labeled and LEED certified buildings with consistent data in the 10 largest metropolitan markets across the US. These markets are New York, Los Angeles (including Orange County), Washington, D.C., Chicago, Dallas, Boston, San Francisco, Atlanta, Philadelphia and Houston.[8] These urban areas capture a large share of the national office market, yet are sufficiently diverse regarding their industry composition, climatic conditions, and vintage of office stock to allow for generalization of the results. As a control group, we select non-certified buildings that are in the same geographic area (submarket) as the certified buildings. To achieve comparability, we only consider certified buildings in submarkets with at least 10 non-certified buildings. Based on these selection criteria, the sample comprises a total of 7,140 buildings of which 1,584 are Energy Star labeled, 337 are LEED certified, and the remainder consists of non-certified buildings. All variables that are time-varying, such as rents, vacancy rates, and unemployment rates, are collected quarterly from 2000 Q1 to 2009 Q4. This generates 40 observations per cross-section unit. For the DID models we also collect data on the building characteristics.

Information on the year of certification is obtained from CoStar and the Energy Star homepage.[9] MSA specific market conditions and unemployment rates come from CoStar and the Bureau of Labor Statistics.

Table 1 provides the variable definitions and basic statistics along with a comparison of building features, rents, and vacancy rates of certified buildings with those of the non-certified buildings in the sample. In Q4 2009, average rent per square foot in Energy Star buildings is $2.8 higher than the sample average. LEED certified buildings have an even larger nominal rent premium of $4.75 per square foot. Figure 1 compares the average rent of certified buildings with that of non-certified buildings over time. Over the entire observation period, certified buildings have a higher average rent level than the non-certified control buildings. However, from 2006 onwards, the difference between both rental rate series increases.

- Insert Table 1 here -

- Insert Figure 1 here-

Energy Star buildings are marginally newer than the buildings in the non-certified sample, whereas LEED buildings are, on average, 10.5 years newer than the non-certified buildings. Energy Star buildings are also taller, have a higher rentable building area and a lower vacancy rate than the non-certified control buildings. LEED certified buildings tend to be larger, have a greater land area and a lower vacancy rate than the non-certified buildings. Figure 2 shows how the number of Energy Star and LEED certified buildings in the sample increases over time. In the Energy Star case, most certifications take place in 2007, 2008, and 2009, which emphasizes the increased interest in the topic in recent years. In the LEED case, most buildings in the sample are also certified after 2007.

- Insert Figure 2 here-

3.2 Methodology

A simple comparison of average rents shows that certified buildings command higher rents, but it does not indicate causation as certified buildings tend to have superior building features. Therefore, one would expect higher rents in this group even without certification. Hedonic modeling is the standard technique for controlling for these differences. They identify the price determinants of building- and location-specific characteristics (Rosen, 1974, Ekeland et al., 2002). Compared to previous studies on this topic, we apply a new identification strategy in that we estimate the effect of certification through the variation of each building's rent over time.

We first analyze the average certification effect for Energy Star labeling and LEED certification with a difference-in-difference (DID) estimator. The DID estimator compares certified and control buildings in the same submarket in terms of outcome changes over time relative to the pre-certification period. To control for the systematic difference between the certified and non-certified buildings, we use two observations for each building, one before certification and one after.[10] Thus, the sample is separated into four groups: buildings before their date of certification, buildings after their certification, control group buildings before certification, and control group buildings after certification. For each certification year we take the rent of the second quarter of the year prior to the certification and the rent of the third quarter of the year after the certification.[11] The data for both quarters and for both certified and control buildings are pooled and the certification effect is calculated with the following regression:

$$lnR_{it} = \beta_0 + \beta_1 CERT_{it} * T_{it} + \beta_2 CERT_{it} + \beta_3 T_{it} + \beta_4 A_{it} + \beta_5 RV_{it} \quad (1)$$
$$+\beta_6 lnS_{it} + \beta_7 lnRBA_{it} + \beta_8 lnL_{it} + \beta_9 lnBC_{it} + \beta_{10} UE_{it} + \beta_{11} SU_{it} + \varepsilon_{it},$$

where the dependent variable is the logarithm of the rent per square foot (*lnR*) and where *T* is a 0/1indicator variable. *T* is one for the quarter when rent is measured after certification and zero for the quarter when rent is measured before the certification. *CERT* is a 0/1 indicator variable, which takes the value 1 if a building belongs to the certification group and 0 otherwise. Buildings belong to the certification group if they get certified in the year of analysis. The coefficient of the interaction term between variables $CERT$ and T (β_1) measures the impact of certification on rents. $CERT$ and T are included separately to captures any separate mean effects of time as well as the effect of belonging to the certification group or not, which controls for systematic differences between the two groups. Additional control variables capture systematic differences between the certified and non-certified buildings. In Equation (1), *A* is the building age, measured from the year of construction, *RV* is the time since the last major refurbishment, *S* is the number of stories of the building, *RBA* is the rentable building area, *L* represents the lot size, *BC* are control variables for building class (standard categories A, B, and C), *SU* are controls for the submarkets (281 in total), and ε is the error term.[12] In order to control for different economic adjustments across MSAs, the unemployment rate (*UE*) of the MSA, in which a building is located, is included.

For Energy Star labeling, the DID analysis is performed for the labeling years 2004 to 2008; for LEED, it is performed for the years 2008 and 2009. For each certification year, the control sample only comprises buildings that never get certified and that are located in the same submarket as the certified buildings. We use the same type of analysis to check the impact of certification on rents and on the outcome variable occupancy rate.

In a next step, the two-period model is extended to multiple time periods and the fixed-effects approach is used to determine the effect of certification.[13] The time series now includes quarterly data from Q1 2000 to Q4 2009. A major attraction of the fixed-effects model over pure cross-sectional regressions is the ability to control for unobserved heterogeneity and to consider dynamic aspects. The fixed-effects model assumes that the unobserved individual characteristics are potentially correlated with the observed regressors. This unobserved effect cannot be consistently estimated and, therefore, is removed through time-demeaning the data. Pooled OLS can now be applied on the time-demeaned variables to estimate the unbiased effect of certification. Time-invariant building characteristics as the number of stories, the rentable building area, or submarket indicator variables cannot be explicitly included in the hedonic model as they would drop out in the transformation.[14] However, building fixed-effects account for all time-invariant variables of the building, including location.

Our log-linear hedonic model, which relates office rents to time-variant building characteristics and economic conditions, takes the following functional form,

$$lnR_{it} = \beta_0 + \beta_1 ES_{it} + \beta_2 LEED_{it} + \beta_3 A_{it} + \beta_4 RV_{it} + \beta_5 V_{it-1} + \beta_6 V_{it-2} + \beta_7 V_{it-3} + \beta_8 V_{it-4} + \beta_9 UE_{it} + \beta_{10} COS_{it} + \beta_{11} VMSA_{it} + c_i + c_t + \varepsilon_{it}, \quad (2)$$

where the dependent variable is the logarithm of the rent per square foot (*lnR*). The focus variables Energy Star (*ES*) and *LEED* certification are 0/1 indicator variables, which take the value of 1 for all quarters after a building is certified and 0 before that or if no certification is present at any time.[15] Several building characteristics are controlled for, such as the age of the building (*A*) or whether a building has been renovated (*RV*). *V* controls for the past vacancy rate of the building as landlords are likely to adjust their rents in response to previous vacancy rates. Previous studies have found an inverse relationship between the vacancy rates and rents, including those by Mills (1992) and Glascock et al. (1990). Building fixed-effects (c_i) are included in all models to account for all time-invariant variables. Time fixed-effects (c_t) are included in the models to control for macroeconomic changes over time, which have an influence on all buildings. In addition, the models account for different unemployment rates (*UE*) in the ten markets. For some models, we also control for variations in the office market conditions with the change in office stock (*COS*) and the vacancy rate (*VMSA*) of the different MSAs. Equation (2) is also estimated with the occupancy rate as the dependent variable.

In a next step, we test whether the age of the Energy Star and/or LEED certification causes any differential pricing effects. We do this by including in Equation (2) an interaction term between the certification variable and an indicator variable for the year of certification. This variable is set to 1 in all periods if a building is labeled or certified in a specific year and 0 otherwise. The interaction term is 1 for all quarters after a building is labeled or certified, but only for those buildings which are labeled or certified in a the year specified by the indicator variable.[16] Repeating this analysis for each labeling and certification year allows us to determine the rent premium for each cohort of Energy Star rated and LEED certified buildings (buildings labeled or certified in a given year). In Equation (3), which we use as an example to illustrate the procedure,

$$lnR_{it} = \beta_0 + \beta_1 ES_{it} + \beta_2 ES_{it} * I(ES\ Label = 2006) + \beta_3 LEED_{it} + \beta_4 A_{it} + \beta_5 RV_{it} + \beta_6 V_{it-1} + \beta_7 V_{it-2} + \beta_8 V_{it-3} + \beta_9 V_{it-4} + \beta_{10} UE_{it} + c_i + c_t + \varepsilon_{it}, \quad (3)$$

$\beta_1 + \beta_2$ is the rent premium for buildings which receive the Energy Star label in 2006. This analysis is performed for Energy Star labels from 2004 to 2009 and for LEED certificates for the years 2008 and 2009.

The relatively long time series per cross-section unit also allow us to analyze how the average rent premium has changed over time. As mentioned in the previous section, we expect *a priori* that the average rent premium has increased in recent years in line with heightened public and industry awareness of environmental and energy efficiency issues. An inspection of media reports on LEED and Energy Star shows that the take-off phase for these products occurred in the first half of 2006. To illustrate the evolution of differential green pricing, we then estimate a *green rental premium index* from Q4 2004 to Q4 2009 by including interaction terms between the Energy Star variable and an indicator variable for each quarter, starting with 2004 Q4. The coefficient of each interaction term represents then the marginal rent premium of the corresponding quarter over the previous period. By adding the coefficients of all previous quarters up to and including quarter *t* we can determine the effect of certification in quarter *t*. In Equation (4),

$$lnR_{it} = \beta_0 + \beta_1 ES_{it} + \beta_2 ES_{it} * I(t \geq 2004{:}4) + \beta_3 ES_{it} * I(t \geq 2005{:}1) \quad (4)$$
$$+\beta_4 ES_{it} * I(t \geq 2005{:}2) + \ldots,$$

β_1 is the effect of Energy Star certification before Q4 2004. The effect of Energy Star labeling on rents in 2004 Q4 can be calculated by summing up $\beta_1 + \beta_2$; the effect in Q1 2005 by calculating the sum $\beta_1 + \beta_2 + \beta_3$, and so forth.

4. Results

Tables 2 and 3 show the results of the DID estimations from 2004 to 2008 for Energy Star labels and for 2008 and 2009 for LEED certification. Each regression includes the focus variable for certification, the building characteristics, and a set of submarket indicator variables. Column 1 in Table 2 presents the results of the DID estimation for Energy Star labeling in 2004 using the pooled data observed in 2003 Q2 and 2005 Q3. The model explains about 69% of the variation in rents and the coefficients of the hedonic variables for building quality, age, and size are consistent with expectations.[17] The age categories all have negative coefficients as the base case relates to newly constructed buildings. Buildings that have previously been renovated command higher rents. The coefficient of the interaction term between *ES* and *T* (*ES***T*) gives the effect of Energy Star labeling in 2004. The results indicate that an Energy Star label in 2004 increases the rent by 3.5%. The same analysis is performed in Models 2, 3, 4, and 5 for Energy Star labels awarded in 2005, 2006, 2007, and 2008, respectively. For Energy Star labels obtained in 2005, 2006, and 2007 we find rental premiums of 3.3%, 6.1%, and 5.0% respectively. The rent premium is insignificant for the 2008 cohort. If we explain the variation in occupancy rates, we find that Energy Star labels lead to a significant increase in occupancy rates: 3.4%, 3.3%, and 2.8% in the years 2006, 2007, and 2008.

Since many LEED buildings in our sample have been certified in 2008 and 2009, we compute the DID models separately for those years. The results of models 6 and 7, however, do not show a significant rent premium for LEED certification in those years nor is there a significant effect of LEED certification on the occupancy rates for these years.

- Insert Table 2 here –

- Insert Table 3 here –

Table 4 presents the results of the fixed-effects models which relate the log rent per square foot and the occupancy rate to the time-varying hedonic characteristics of the building. Altogether the models explain some 85 percent of the rent and 70 percent of the occupancy rate. Time fixed-effects are jointly significant in all models. Column 1 shows the results for the rent estimation. The coefficients of the age categories and renovation have the expected signs. Previous vacancy rates have a significant and negative influence as high vacancy rates force building owners to lower rents. The unemployment rate has a statistically significant negative coefficient. The results reveal that Energy Star labeling leads on average to a rent premium of 2.5%, whereas LEED certification leads to a slightly higher rent premium of 2.9% over the observation period. The results in Column 2 show that Energy Star labeling also leads to an increase in occupancy rates of 4.5%. This result is in accordance with those of Miller et al. (2008) and Fuerst and McAllister (2009, 2011b), who find occupancy rates to be 2-4% higher for Energy Star labels. In models 10 and 11 we add the vacancy rate of each MSA and the change in the office stock to control for office market conditions that vary by region. However, the effects of Energy Star and LEED on rents and occupancy rates do not change significantly.

- Insert Table 4 here -

In a next step we analyze the market implications of Energy Star labels and LEED certificates awarded in a given year. Table 5 shows the results of the fixed-effects estimation when we explicitly consider the year of labeling or certification. The results show that the rent premium varies with the year of certification. Energy Star labels awarded in 2004 lead to an average rent premium of 6.1%, Energy Star labels awarded in 2005 to a rent premium of 7.0%. For Energy Star labels awarded in the years 2006, 2007, 2008 and 2009, the average rent premiums are 4.8%, 3.5%, 2.5%, and 2.9%, respectively. These results indicate that the rent premium is positively associated with the time elapsed since certification occurred. In other words, the longer a building has been labeled, the higher is the rent premium it commands. For LEED certification the opposite is the case. Buildings which received a LEED certificate in 2006, on average, only command a rent premium of 2.9%, whereas buildings, which receive a certificate in 2009, command a rent premium of 3.9%.

- Insert Table 5 here –

It is often argued that certification is carried out in combination with a major renovation of the building. Although we control for renovation in our models, in a separate model we test whether pure certification has an influence on rents by excluding all buildings from the sample which have been renovated within three years prior to certification. The results of the fixed-effects models do not differ from the results presented above, which suggests that the effect predominantly comes from certification, not from renovation.

We map the entire dynamic behavior of the rent premium for Energy Star in the next step. Table 6 shows the rent premium for each quarter from Q4 2004 to Q4 2009 using the model described by Equation (4). The resulting coefficients are illustrated in the *'green' rental premium index* in Figure 3. The results indicate that no statistically significant rent premium can be identified before Q4 2006 when for the first time a rent premium of 2.5% for Energy Star is found. The rent premium increases in subsequent periods and reaches 7% in the first half of 2008. These results are in line with the demand and supply dynamics of eco-certified buildings presented earlier and suggest that increased public awareness and the demand for sustainable buildings in 2006 and 2007 may be driving the rent premium. The results further show that the strong economic downturn had an effect on the rent premium. Although the rent premium for Energy Star labeled buildings remains positive, it decreases to 3.7% at the end of 2009.

- Insert Table 6 here -

- Insert Figure 3 here -

5. Conclusion

Expanding on previous cross-sectional studies, this paper provides further evidence on the dynamics of the rent premium of LEED certification and Energy Star labeling in the U.S.

Difference-in-differences (DID) and fixed-effects models are used to determine the effect of LEED and Energy Star on rents of commercial office buildings. The results of the empirical analysis confirm the expectation of a rent premium. The results of the DID estimation confirm a rent premium for Energy Star from 2004 to 2007. The results of the fixed-effects models suggest that an Energy Star increases rents by 2.5% and an LEED certificate by 2.9%, averaged over all time periods in the analysis. We also find a positive relationship between rent premium and the time since an Energy Star label was awarded. For LEED certification the opposite is the case. The rent premium for Energy Star rated buildings changes considerably over time. It strongly increases from 2006 Q4 until 2008 Q2, when the rent premium peaks at 7%. In subsequent periods, the rent premium decreases. We also find a positive relationship between Energy Star and occupancy rates.

Regarding future work, it will be interesting to study the further development of differential *green* pricing. Certification standards are likely to evolve further and it seems likely that a distinct group of certified buildings will persist even as the general stock of buildings becomes more energy-efficient through new regulations and incentives. The interaction effects of multiple certifications and environmental benchmarks for individual properties on pricing are also likely to gain importance as a marker of distinction in environmental performance. Within this area, further studies might consider the effect of Energy Star certification date and re-certification to capture the rapidly evolving standards. There is also scope for enriching the existing econometric models with additional variables, such as lease arrangements and actual energy consumption patterns that are not accessible to researchers to date, but may increase our understanding of dynamic pricing patterns for energy efficiency and sustainability features in real estate markets and contribute to the broader body of literature on differential pricing of eco-labeled products.

[1]A number of terms is used synonymously for sustainability in the real estate industry, the most common of these being Green Building, Energy Efficiency, Eco-Efficiency, Environmental Efficiency, Zero Carbon and High Performance Building. Most of these terms focus primarily on environmental aspects, while sustainability set out to be a much broader concept which also considers economic and social aspects (Elkington, 1998). Lützkendorf and Lorenz (2007) define a sustainable building to be a building with optimized life cycle costs, which avoids or minimizes the harm to the environment, occupants, and neighbors of the building.

[2]These numbers are taken from the USGBC project list, available at http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx.

[3]The savings can be particularly large for tenants with net lease arrangements. However, only approximately 18% of the certified and non-certified buildings used for this study have a net lease contract which is roughly in line with the general market share.

[4]Eichholtz et al. (2010a) and Eichholtz et al. (2010b) disentangle the rent premium in more detail. However, the information on the historic energy consumption of both the certified buildings and the control buildings, which is necessary to disentangle the premium in this study, are not available to the authors.

[5]A search in newspapers for 'Green Building' via Lexis Nexis shows that the number of hits increases from 1,010 hits in 2000 to 2,896 in 2005 and to more than 3,000 in 2006. A search via newslibrary.com, which includes 3,312 newspapers and other news sources in the US, returns 402 hits in 2000, 3,501 hits in 2005, 13,939 in 2007 and 18,432 in 2009. A search in the Google news archive also reveals a drastic increase from 2006 to 2008.

[6]The average rent of the ten markets in the analysis decreases by 7.7% from 2008 Q1 to 2009 Q4.

[7]Pivo and Fischer (2010) use panel regression as a robustness test to confirm their findings. However, no details are given about their model specifications.

[8]According to a ranking by Betterbricks and Cushman & Wakefield (2010), six of these markets are among the Top 10 "greenest" cities regarding green building adoption and implementation (Betterbricks and Cushman & Wakefield, 2010).

[9]http://www.energystar.gov/index.cfm?fuseaction=labeled_buildings.locator

[10]Similar to the fixed-effects estimation, DID allows to control for unobserved heterogeneity as DID assumes that this unobserved heterogeneity is time-invariant and is canceled out through differencing (Revallion, 2008).

[11]We conduct a comprehensive sensitivity analysis in which we use the previous and the following periods to estimate the DID. The results, however, do not change significantly.

[12] An important caveat is that our submarket indicator variables do not control perfectly for unobserved spatial heterogeneity. Although submarket boundaries are intended to delineate relatively homogenous market areas, it is possible that intra-submarket variations in locational quality and accessibility might give rise to biased results if certified buildings were systematically located in the best and most accessible locations within submarkets. In the DID model, two conditions would have to be met for this bias to arise: 1) certified buildings are systematically located in the best micro-locations while non-certified buildings are found in worse locations and 2) price and rental paths of good and bad micro-locations diverge over time due to factors that are not captured by the control variables. Considering the relatively small number of certified buildings compared to control buildings, a bias seems highly unlikely. However, to rule this out empirically, detailed accessibility measures would have to be obtained and included in the model. Such measures are now available from CoStar for a subset of about 40% of the properties considered in our analysis. Apart from the reduction in sample size, there is a danger that this might introduce selection bias as the properties for which this information is available are probably a non-random subset of our sample. Hence, we do not pursue this possibility further.

[13]Fixed-effects models are used because the Hausman test rejects the consistency of the random effects estimator at high levels of statistical significance. In this study the fixed-effects models are estimated by de-meaning all variables, not by using the least squares dummy variable method.

[14]The fixed-effects estimator (within estimator) exploits the variation of the data over time as it measures the association between individual-specific deviations of regressors from their time-averaged values and individual-specific deviations of the dependent variable from its time-averaged values. Time-invariant variables, therefore, drop out of the model.

[15]The indicator variable for Energy Star certification takes the value 1 after the first certification. Multiple certifications are not captured in the model. In a separate model, however, we integrate into the model an indicator variable which takes the value 1 if a building is Energy Star labeled more than once. We then interact the Energy Star variable and the indicator variable for multiple certifications. The results show that buildings that have multiple Energy Star labels command a higher rent premium than building that have only one Energy Star label. Accordingly, the fixed-effects estimation shows that buildings with only one Energy Star label do not

command a statistical significant rent premium, whereas buildings with multiple Energy Star labels command a rent premium of 3.3%. This issue should be further explored in future research.

[16]Building, which are Energy Star labeled in 2006, should serve as an example here: The Energy Star variable is 1 from the Energy Star labeling onwards. The indicator variable for Energy Star labeling in 2006 is 1 in every period for those buildings, which receive the Energy Star label in 2006, 0 for all other buildings. The interaction term between those variables, thus, is 1 from 2006 onward for those buildings which receive the Energy Star label in 2006.

[17]Earlier studies on the determinants of rents, for example, include those by Clapp (1980), Frew and Judd (1988), Bollinger et al. (1998), and Slade (2000).

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Acknowledgements: We would like to thank the CoStar Group for providing us with access to their database. The authors are also grateful to John L. Glascock and the participants of the 26th Conference of the American Real Estate Society in Naples for their comments and suggestions on an earlier version of this paper. Three anonymous referees and the editor of this journal provided valuable comments and guidance that improved the quality of this article.

Table 1: Definition of Variables and Basic Statistics

Variable	Description	Mean	Stand. Dev.	Observ.
Overall sample				
TGR	Total gross rent in dollars per square foot adjusted for the Consumer Price Index	20.347	7.757	5515
ES	1 if building is Energy Star labeled, 0 before certification and if no certification is present	0.221	0.415	7140
LEED	1 if building is LEED certified, 0 before certification and if no certification is present	0.047	0.212	7140
A	Age of the building in years	29.340	23.004	7016
RV	Years since last major renovation			
S	Number of stories	8.665	10.223	7129
RBA	Rentable Building Area in sq. ft.	200473	270938	7140
L	Site area	7.759	150.579	6425
BC	Building Class - standard categories A, B, and C			
V	Vacancy rate of building	0.240	0.246	6882
UE	Unemployment rate of MSA in which building is located	9.212	1.732	7140
COS	Change in office stock of MSA in which a building is located	0.001	0.001	7166
VMSA	Vacancy rate of MSA in which a building is located	0.137	0.022	7166
Energy Star buildings				
TGR	Total gross rent in dollars per square foot adjusted for the Consumer Price Index	23.136	7.945	1050
A	Age of the building in years	27.027	18.706	1570
S	Number of stories	14.103	13.068	1573
RBA	Rentable Building Area in sq. ft.	345468	335765	1576
L	Land Area	7.255	26.579	1392
V	Vacancy rate of building	0.151	0.173	1374
LEED buildings				
TGR	Total gross rent in dollars per square foot adjusted for the Consumer Price Index	25.089	9.508	159
A	Age of the building in years	18.876	23.472	314
S	Number of stories	11.236	11.212	330
RBA	Rentable Building Area in sq. ft.	318911	359991	336
L	Land Area	13.337	26.792	265
V	Vacancy rate of building	0.201	0.301	303

Notes: Rental rates, vacancy rates, building characteristics, information on renovation and LEED certification, change in office stock, and vacancy rates of the MSAs were drawn from the CoStar database; information on the date of Energy Star certification was drawn from CoStar and the Energy Star homepage; unemployment rates were drawn from The Bureau of Labor Statistics. The data represents the basic statistics for the cross-section in 2009 Q4.

Table 2: Difference-in-Differences Estimation (Dep. Variable: log of TGR)

	Model 1	Model 2	Model 3	Model 4
Year of ES certification	2004	2005	2006	2007
ES*T	0.035**	0.033*	0.061***	0.050***
	(0.015)	(0.018)	(0.012)	(0.010)
ES	-0.032***	-0.026**	-0.027***	0.000
	(0.012)	(0.012)	(0.009)	(0.008)
T	-0.096***	-0.104***	-0.039***	0.021***
	(0.005)	(0.008)	(0.007)	(0.006)
Age				
4-10 years	-0.071***	-0.110***	-0.093***	-0.113***
	(0.011)	(0.011)	(0.012)	(0.010)
11-16 years	-0.124***	-0.145***	-0.134***	-0.133***
	(0.010)	(0.011)	(0.014)	(0.013)
17-19 years	-0.138***	-0.170***	-0.160***	-0.164***
	(0.010)	(0.011)	(0.012)	(0.011)
20-22 years	-0.169***	-0.193***	-0.179***	-0.180***
	(0.010)	(0.010)	(0.012)	(0.011)
23-24 years	-0.171***	-0.215***	-0.206***	-0.206***
	(0.012)	(0.012)	(0.013)	(0.011)
25-28 years	-0.199***	-0.236***	-0.212***	-0.217***
	(0.012)	(0.012)	(0.014)	(0.011)
29-35 years	-0.188***	-0.221***	-0.212***	-0.227***
	(0.012)	(0.013)	(0.014)	(0.012)
36-50 years	-0.197***	-0.214***	-0.226***	-0.227***
	(0.014)	(0.014)	(0.015)	(0.012)
>51 years	-0.210***	-0.269***	-0.271***	-0.272***
	(0.016)	(0.016)	(0.017)	(0.015)
Years since renov.				
1-3 years	0.038***	0.038***	0.033***	0.033***
	(0.009)	(0.008)	(0.009)	(0.009)
4-6 years	0.030***	0.009	0.013	0.010
	(0.011)	(0.011)	(0.011)	(0.011)
7-9 years	0.001	0.015	0.004	0.019*
	(0.010)	(0.013)	(0.011)	(0.010)
>10 years	0.008	0.006	0.012	0.002
	(0.008)	(0.008)	(0.008)	(0.007)
RBA (log)	0.001	0.006	0.002	0.006
	(0.006)	(0.006)	(0.005)	(0.005)
Stories (log)	0.072***	0.070***	0.076***	0.071***
	(0.006)	(0.006)	(0.006)	(0.006)
Site area (log)	0.005*	-0.001	0.003	0.001
	(0.003)	(0.003)	(0.003)	(0.003)
Building Class				
Class B	-0.082***	-0.089***	-0.090***	-0.094***
	(0.006)	(0.006)	(0.006)	(0.006)
Class C	-0.188***	-0.168***	-0.179***	-0.189***
	(0.018)	(0.015)	(0.015)	(0.016)
Unempl. Rate (-4)	-0.170***	-0.108***	-0.116***	-0.054***
	(0.009)	(0.007)	(0.007)	(0.010)
Constant	3.811***	3.609***	3.519***	3.257***
	(0.073)	(0.064)	(0.064)	(0.129)
Submarket Controls	Yes	Yes	Yes	Yes
Adjusted R^2	0.69	0.71	0.73	0.73
Root MSE	0.182	0.182	0.185	0.190
Sample Size	8197	8313	8901	9442

Notes: Table shows results of the difference-in-differences estimation within a regression framework with the logarithm of the total gross rent adjusted for the consumer price index as the dependent variable. For each certification year we take data on the rent of the second quarter of the year before certification and data on the rent of the third quarter of the year after certification. The data over both time periods and across certification status are pooled and the certification effect is calculated based on Equation (1). Standard Errors are in parentheses. * indicates significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 3: Difference-in-Differences Estimation (Dep. Variable: log of TGR)

	Model 5	Model 6	Model 7
Year of ES certification	2008		
Year of LEED certification		2008	2009
ES*T	0.003		
	(0.010)		
ES	0.021***		
	(0.007)		
LEED*T		0.026	0.005
		(0.037)	(0.022)
LEED		-0.032	0.016
		(0.029)	(0.017)
T	0.029***	0.070***	0.066***
	(0.007)	(0.011)	(0.012)
Age			
4-10 years	-0.103***	-0.094***	-0.102***
	(0.011)	(0.018)	(0.012)
11-16 years	-0.119***	-0.133***	-0.096***
	(0.014)	(0.024)	(0.015)
17-19 years	-0.144***	-0.137***	-0.130***
	(0.012)	(0.021)	(0.014)
20-22 years	-0.170***	-0.154***	-0.156***
	(0.012)	(0.019)	(0.013)
23-24 years	-0.197***	-0.199***	-0.181***
	(0.012)	(0.020)	(0.013)
25-28 years	-0.208***	-0.202***	-0.207***
	(0.012)	(0.019)	(0.012)
29-35 years	-0.210***	-0.206***	-0.206***
	(0.013)	(0.022)	(0.014)
36-50 years	-0.225***	-0.201***	-0.233***
	(0.013)	(0.022)	(0.015)
>51 years	-0.263***	-0.277***	-0.256***
	(0.016)	(0.027)	(0.019)
Years since renov.			
1-3 years	0.022**	0.021	0.023*
	(0.011)	(0.019)	(0.014)
4-6 years	0.032***	0.007	0.032**
	(0.011)	(0.022)	(0.016)
7-9 years	0.000	-0.016	0.002
	(0.010)	(0.018)	(0.013)
>10 years	0.006	-0.023*	0.009
	(0.007)	(0.014)	(0.009)
RBA (log)	0.002	0.014	0.016***
	(0.005)	(0.010)	(0.006)
Stories (log)	0.073***	0.037***	0.063***
	(0.006)	(0.011)	(0.007)
Site area (log)	0.002	0.001	-0.003
	(0.003)	(0.006)	(0.004)
Building Class			
Class B	-0.091***	-0.111***	-0.092***
	(0.006)	(0.011)	(0.008)
Class C	-0.185***	-0.206***	-0.196***
	(0.013)	(0.023)	(0.020)
Unempl. Rate (-4)	-0.041***	-0.072***	-0.065***
	(0.003)	(0.007)	(0.006)
Constant	3.213***	3.404***	3.667***
	(0.059)	(0.135)	(0.171)
Submarket Controls	Yes	Yes	Yes
Adjusted R^2	0.71	0.66	0.73
Root MSE	0.195	0.203	0.201
Sample Size	10121	2975	6286

Notes: Table shows results of the difference-in-differences estimation within a regression framework with the logarithm of the total gross rent adjusted for the consumer price index as the dependent variable. For each certification year we take data on the rent of the second quarter of the year before certification and data on the rent of the third quarter of the year after certification. The data over both time periods and across certification status are pooled and the certification effect is calculated based on Equation (1). Standard Errors are in parentheses. * indicates significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 4: Results from Fixed-Effects Estimation (Dep. Variable: log of TGR and occupancy rates)

	Model 8	Model 9	Model 10	Model 11
Dep. Variable	Rent (log)	Occup. Rate	Rent (log)	Occup. Rate
Energy Star	0.025***	0.045***	0.025***	0.045***
	(0.006)	(9.44)	(0.006)	(9.16)
LEED	0.029*	-0.017	0.028*	-0.019
	(0.016)	(-1.19)	(0.016)	(-1.27)
Age				
4-10 years	-0.046***	0.088***	-0.047***	0.092***
	(0.007)	(9.59)	(0.007)	(9.64)
11-16 years	-0.066***	0.090***	-0.070***	0.095***
	(0.012)	(5.46)	(0.011)	(5.47)
17-19 years	-0.070***	0.095***	-0.075***	0.104***
	(0.013)	(4.89)	(0.013)	(5.02)
20-22 years	-0.082***	0.097***	-0.088***	0.107***
	(0.014)	(4.43)	(0.014)	(4.56)
23-24 years	-0.089***	0.103***	-0.098***	0.116***
	(0.015)	(4.28)	(0.015)	(4.47)
25-28 years	-0.090***	0.107***	-0.099***	0.121***
	(0.017)	(4.01)	(0.016)	(4.21)
29-35 years	-0.088***	0.108***	-0.097***	0.129***
	(0.019)	(3.58)	(0.018)	(3.92)
36-50 years	-0.081***	0.105***	-0.090***	0.132***
	(0.022)	(3.03)	(0.021)	(3.52)
>51 years	-0.051*	0.085**	-0.050*	0.119***
	(0.028)	(1.99)	(0.027)	(2.59)
Years since renov.				
1-3 years	0.038***	-0.029**	0.034***	-0.031***
	(0.008)	(-2.49)	(0.008)	(-2.63)
4-6 years	0.023**	0.051***	0.021**	0.048***
	(0.010)	(3.73)	(0.010)	(3.38)
7-9 years	0.027**	0.063***	0.015	0.057***
	(0.012)	(4.03)	(0.012)	(3.51)
>10 years	0.027*	0.058***	0.012	0.051***
	(0.014)	(3.24)	(0.014)	(2.74)
Vacancy rate (-1)	-0.035***		-0.026***	
	(0.005)		(0.005)	
Vacancy rate (-2)	-0.008***		-0.008***	
	(0.003)		(0.003)	
Vacancy rate (-3)	-0.010***		-0.009***	
	(0.003)		(0.003)	
Vacancy rate (-4)	-0.032***		-0.040***	
	(0.005)		(0.005)	
Unempl. Rate (-4)	-0.049***	-0.017***	-0.029***	-0.004
	(0.002)	(-6.55)	(0.002)	(-1.29)
Vacancy Rate (MSA)			-1.181***	-1.250***
			(0.108)	(-9.31)
Change Office Stock			2.397***	-0.190
			(0.247)	(-0.43)
Constant	3.340***	0.794***	3.409***	0.902***
	(0.014)	(35.72)	(0.017)	(35.96)
Adjusted R^2	0.85	0.70	0.86	0.71
Root MSE	0.137	0.236	0.130	0.239
Observations	159314	237419	151996	220675
Cross-sectional Units	6423	7142	6392	7142
Wald Test: Time FE	78.92***	21.73***	61.35***	3.26***

Notes: Table shows results of panel data regressions using fixed-effects. The dependent variable in models 8 and 10 is the logarithm of the total gross rent adjusted for the consumer price index. The dependent variable in models 9 and 11 is the occupancy rate. Time fixed-effects are included and are jointly significant in all models. Cluster-robust standard errors are used to control for serial correlation in the error and heteroscedasticity. Standard Errors are in parentheses. * indicates significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5: Market Implications of Energy Star Labels and LEED Certificates awarded in a given Year

Year of first label/certificate	Energy Star		LEED	
	Coeff.	Std. Err.	Coeff.	Std. Err.
2004	0.061***	-0.022		
2005	0.070***	0.018		
2006	0.048**	0.019	0.029*	0.016
2007	0.035***	0.011	-0.042	0.043
2008	0.025***	0.008	0.063	0.052
2009	0.029***	0.008	0.039***	0.015

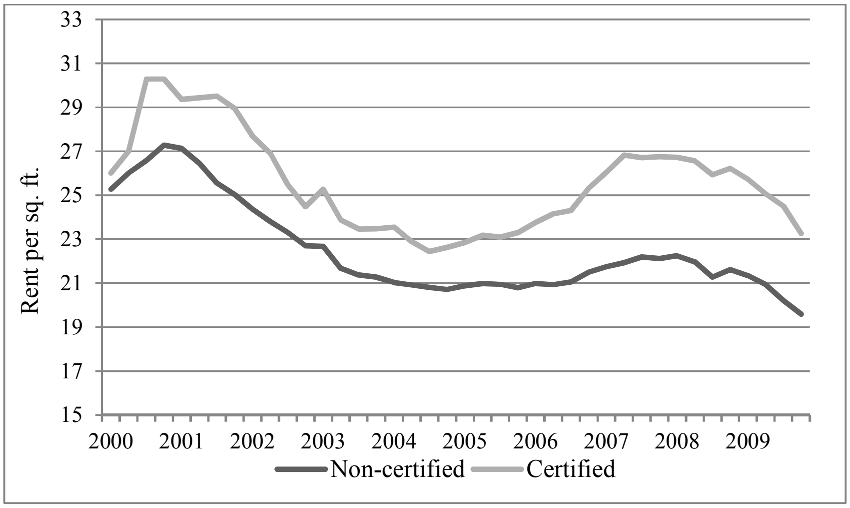
Notes: Table shows the results of the fixed-effects estimation with an interaction term between the certification variable and an indicator variable for the year of certification.

Table 6: Derived Average Rent Premium of Energy Star Labeling over time

	Rent Premium	Std. Err.		Rent Premium	Std. Err.
2004 Q4	-0.009	0.010	2007 Q3	0.056***	0.009
2005 Q1	-0.012	0.009	2007 Q4	0.066***	0.009
2005 Q2	-0.008	0.009	2008 Q1	0.070***	0.010
2005 Q3	-0.008	0.008	2008 Q2	0.070***	0.010
2005 Q4	0.002	0.012	2008 Q3	0.054***	0.007
2006 Q1	0.006	0.012	2008 Q4	0.049***	0.007
2006 Q2	0.015	0.012	2009 Q1	0.045***	0.007
2006 Q3	0.009	0.009	2009 Q2	0.045***	0.007
2006 Q4	0.025**	0.009	2009 Q3	0.045***	0.007
2007 Q1	0.036**	0.011	2009 Q4	0.037***	0.007
2007 Q2	0.052***	0.010			

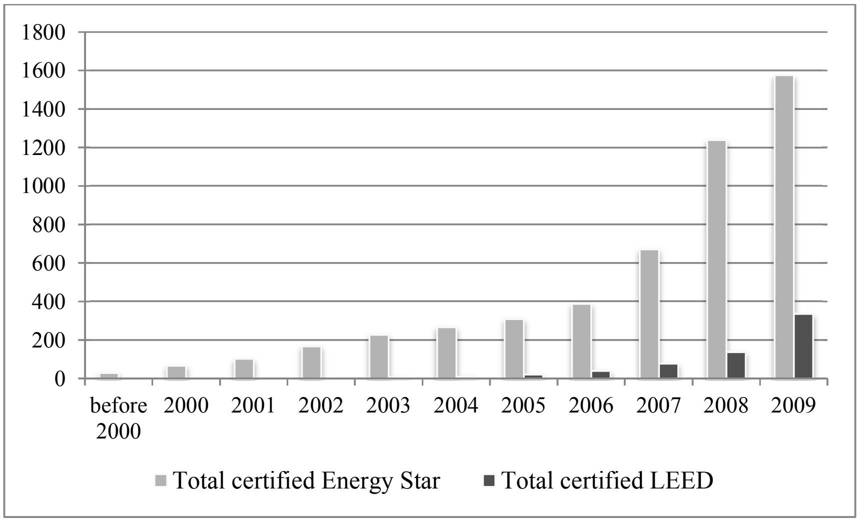
Notes: The rent premiums are estimated with a fixed-effects model including interaction terms between the Energy Star variable and indicator variables for each quarter from 2004 Q4 to 2009 Q4.

Figure 1: Comparison of average rent of certified and non-certified buildings



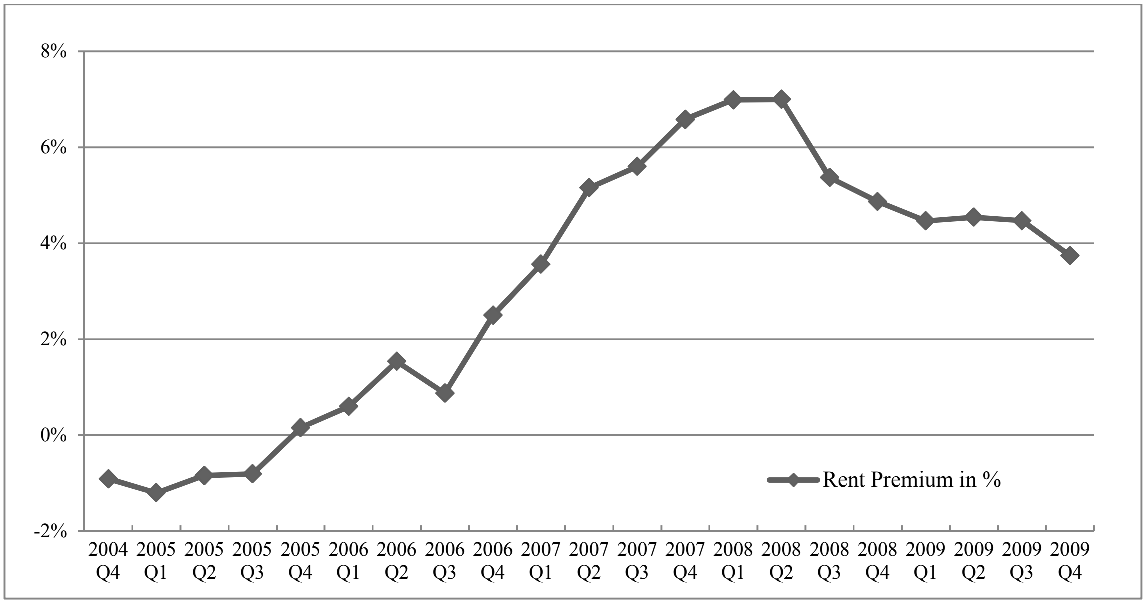
Notes: Certified buildings include buildings which are either LEED certified or Energy Star labeled.

Figure 2: LEED certified and Energy Star labeled buildings in the sample



Notes: The light grey bars represent the total number of Energy Star labeled buildings in each year. The dark grey bars represent the total number of LEED certified buildings in each year.

Figure 3: Estimated average 'Green' rental premium from 2004 Q4 to 2009 Q4



Notes: The rent premiums are estimated with a fixed-effects model including interaction terms between the Energy Star variable and indicator variables for each quarter starting in 2004 Q4. The rent premium in each quarter is the sum of the coefficients of the interaction term of this period and those of all previous periods.